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The Heilmann Suspension for Automobiles

By Jacques Boyer.

In automobiles of the usual construction the center of gravity is higher than the axles. The result is extensive vibration of the vehicle and torsion of the springs. Moreover, the shocks caused by inequalities of the road are transmitted directly from the wheels to the axles. The springs, attached by their middle posts to the axles, follow the oscillations thus produced, but the chassis and the body of the car, which are suspended from the ends of the springs, are prevented by their inertia from following these rapid vibrations. Hence the springs and their connections are strained and are soon worn out. In light cars these defects are party obviated by pneumatic or solid rubber tires, but the vibrations of heavy vehicles cannot be overcome by these very costly additions.

An elegant solution of the difficulty has been proposed by J. J. Heilmann, the inventor of the first electric locomotive. In the Heilmann compound suspension for automobiles all oblique bearings and torsional stresses are eliminated, and the center of gravity is brought as near the ground as possible, while the weight of the car acts along the vertical lines which pass through the centers of the wheels and the points of contact with the ground, but is borne entirely by the hubs, and not by the axles.

The details of construction are shown in Figs. 1 and 2, which represent vertical sections of the vehicle in the planes of the rear and front axles, respectively. The weight of the chassis and body is carried by the rear and front supporters *a*, attached to the longitudinal bars *b* of the chassis. These supporters pass over and outside the wheels and rest on the hubs *c*. Each wheel is absolutely independent. The axles *d* carry no weight except their own, and serve merely to connect the wheels together. They are connected to the front hubs by Cardon joints *e*, and to the rear hubs by balls *f*. Each wheel is consequently free to rise, independently of the others, in surmounting obstacles. The axles move freely in guides *g*, attached to the chassis.

The weight is transmitted to the hubs by the following mechanism: Each hub turns in all bearings *i* in a saddle *h*, which has four lugs, of which two are above and two below the hubs. These lugs are attached by short suspending links to the ends of two carriage springs of the ordinary type *l*, with their concave sides below. The two sheaves *m*, which are bolted to the middle parts of the springs, are connected with each other by an ovoid frame *n*, which surrounds the saddle without touching it at any point.

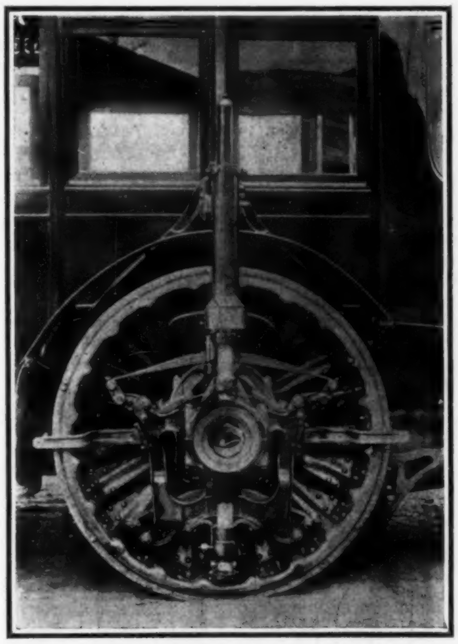


Fig. 5.—WHEEL OF CAR WITH HEILMANN SUSPENSION

The outer portion *o* of the supporter *a* rests on the spiral spring *p*, which rests on the upper spring sheaf *m*. Vertical rods *r* attached to the top and bottom of the saddle *h*, pass through tubes rigidly connected with the upper and lower spring sheaves *m* and guide the wheel in rising over obstacles. The Cardan joints allow the front wheels to be turned around a vertical axis in steering. The tires are composed of chrome leather, very strongly compressed, which nearly eliminates the noise produced by the rolling of the wheels.

The diameter of the wheels is 4 feet and 5 inches, but as the weight is borne by the supporters described above, and not by the axles, the center of gravity can be brought lower than in a car of the usual type with much smaller wheels. The large wheels possess the advantages of better adhesion to the ground, diminished coefficient of traction and smaller velocity of rotation for a given speed of travel—not to speak of their esthetic superiority. The weight of all the springs of a car designed to carry a load of 4½ tons, in addition to its own weight, does not exceed 135 pounds.

Another distinctive feature of the new Heilmann car is a system of steering which is entirely independent of the various connections and mutual reactions between the front wheels and the chassis which are described above, so that the wheels can be turned without regard to their momentary positions relative to the chassis. The mechanism by which this result is produced is shown in Figs. 3 and 4, which represent, respectively, side and front elevations of the steering gear. The rotation of the steering wheel 1, transmitted to the endless screw 2, moves the nut 3, which, by means of the fork 4, causes the bent lever 5 to turn on its point 6, which is attached to the chassis 7. The lever 5 is connected, by the link 8 and the joints 9 and 10, with the support 11, which slides along the guiding rod 12, attached to the chassis by the bars 13. The support 11 has a vertical slot containing the sliding piece 14, which is jointed at 15 to the plunger 16. This plunger penetrates more or less deeply into a cylinder 17, which is attached to the wheel by means of the piece 18.

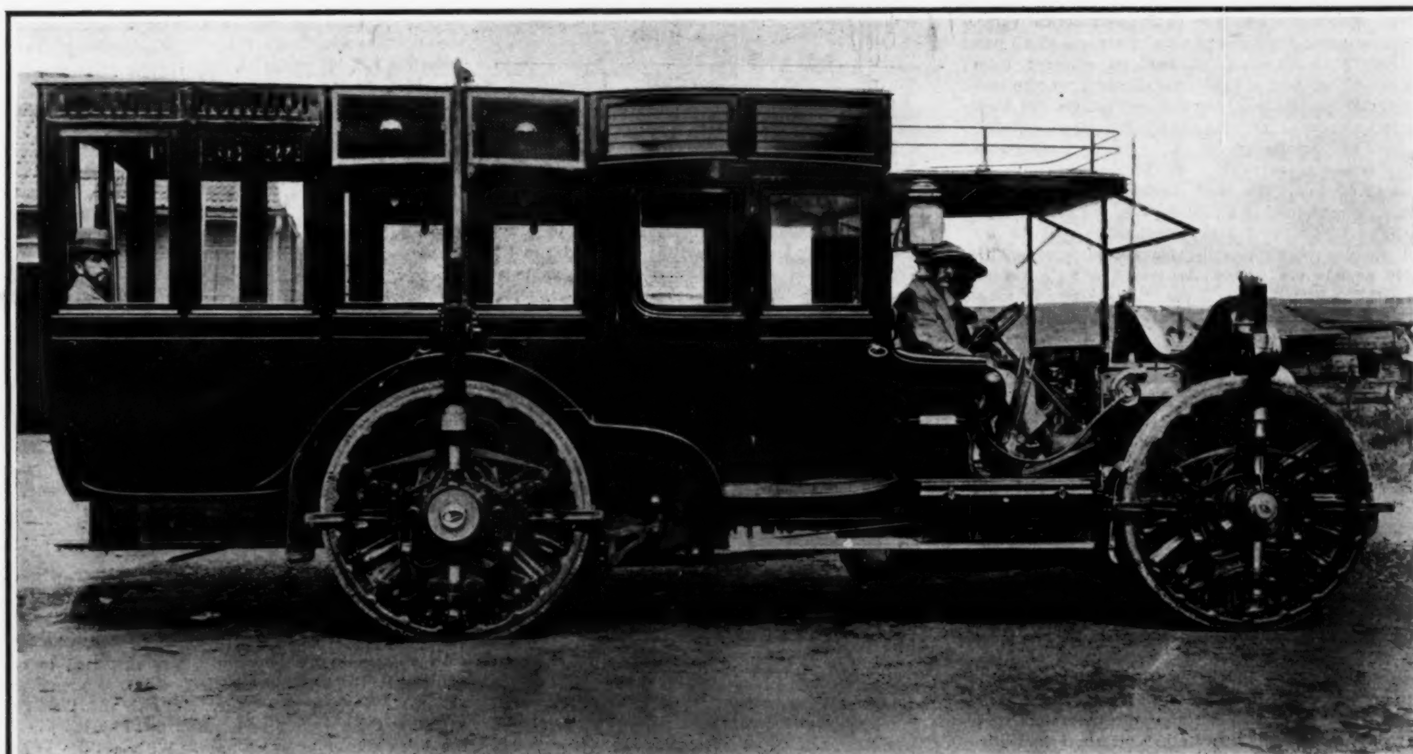


Fig. 6.—THE HEILMANN CAR

Hence, when the support 11 is moved forward or backward by turning the steering wheel 1, as has been explained the motion is transmitted by the sliding piece 14 to the extensible steering lever, which is composed of the plunger 16, the cylinder 17 and the piece 18; and the wheel to which this piece is attached is turned to the right or left, through an angle which corresponds with the position to which the support 11 is moved along the guiding rod 12, and also with the depth to which the plunger 16 penetrates in the cylinder 17. The freedom of movement of the sliding piece 14 in the slot of the support 11 allows the entire steering lever, composed of 16, 17, and 18, to rise and sink with the wheel as the latter passes over obstacles, without interfering with the operation of steering.

The Heilmann car, no doubt, needs some improvement in details, and a more pleasing appearance may be given to the rather heavy vehicle by skillful constructors. In any case, the Heilmann suspension, which aims at no less than the greatly desired elimination of rubber tires, both solid and hollow, constitutes an important advance in automobile construction.

Light-Weight Alloys for Aerial Engines and Aeroplanes.*

It is generally recognized that future improvements in aerial navigation will be greatly facilitated by a decrease in the weight of the machinery. With this end in view metals or alloys of low specific gravity are being eagerly sought to supplant the heavy metals generally in use. The field of investigation, however, is so far very narrow, it being at present limited to the two metals, aluminium and magnesium. The alloys so far developed consist of various proportions of these two elements, modified by small additions of heavier metals.

A number of alloys of this type have been experimented with and several have been patented. The best known are duralum and magnalium. One of the latest discoveries in this line is called duralumin, which is of German origin, as, in fact are most of the light alloys. Extraordinary claims are made for this alloy. It is stated that it has practically all the properties of steel, that it can be drawn, rolled, stamped, or forged, either hot or cold, that its tensile strength ranges from 30,000 to 88,000 pounds per square inch, according to its degree of hardness, and that these qualities are found in an alloy containing from 90 to 95 per cent of aluminium, so that the specific gravity is very nearly that of aluminium.

Duralum contains copper and phosphorus in addition to magnesium. The composition is given as 79 per cent of aluminium, 11 per cent of magnesium, and 10 per cent of phosphor-copper. The percentage of phosphor in the copper is very low—only 0.5 per cent. It is likely that the composition of this alloy, however, is slightly modified in practice, because 10 per cent of copper is exceedingly high, even in the absence of magnesium, and when the hardening effect of 11 per cent of this latter metal is taken into consideration, it would seem that an alloy of the composition as given would be too brittle to be of any practical value.

Magnalium is composed of aluminium and small percentages of magnesium, an analysis showing from 1.58 to 1.60 per cent of this latter element. It also contains small percentages of copper, nickel, tin and lead, the last-mentioned metal probably being an impurity. The specific gravity of this alloy varies from 2.5 to 2.57. According to Prof. J. W. Richards, the tensile strength of magnalium sand castings containing 2 per cent of magnesium is 17,900 pounds per square inch with an elongation of 3 per cent, while with 10 per cent magnesium the tensile strength is increased to 21,400 pounds per square inch, with a 2.4 per cent elongation. It will be seen that the addition of magnesium hardens the metal. Chilled castings of magnalium with 2 per cent magnesium have been found to possess a tensile strength of 28,600 pounds per square inch, with an elongation of 2 per cent, and 10 per cent magnesium alloy chilled castings have a tensile strength of 33,600 pounds per square inch, and an elongation of 3.40 per cent. This is a peculiar condition as compared with that of sand castings. The same peculiarity is found in water-chilled castings, where the 2 per cent alloy has a tensile strength of 40,000 pounds per square inch and a ductility of 1 per cent, while the 10 per cent alloy has a tensile strength of 61,100 pounds per square inch with an elongation of 4.20 per cent.

In another series of light-weight alloys aluminium is replaced by magnesium for the basic metal. This produces a lighter alloy, as the elements of high specific gravity with which the magnesium is alloyed exist only in small proportions. Alloys of this kind contain from 80 to 95.5 per cent of magnesium, the remainder being made up of other metals, principally aluminium. These alloys, it is claimed, can be readily machined, soldered, welded, forged and cast. An alloy of 92 per cent magnesium and 8 per cent aluminium has a specific gravity of 1.75 and is claimed to be equal in strength to the best gun metal, although the metallurgist may doubt this broad statement. The difference in general between gun metal or bronze and the light-weight alloys is that gun metal may combine high tensile strength with great ductility, while the alloys of low specific gravity are more of the nature of cast iron, and high tensile strength is obtained only at the expense of ductility. Various useful magnesium alloys have, however, been produced, such as electron, and ruebel-bronze. These will, no doubt, be found of great value in the construction of aerial machines, but there is a danger of their being discredited by extraordinary claims by the makers which will cause them to be used for purposes for which they are not suited.

There are a number of light-weight metals besides aluminium and magnesium, but there is no likelihood of their being used for practical purposes on account of their scarcity. Among these metals are lithium, rubidium and beryllium. Lithium is the lightest of all metals known, its specific gravity being only 0.57. It possesses, however, but few of the qualities usually associated with metals; it is very soft, and melts at a low temperature, and it is hardly likely that it can be used in sufficient quantity with other metals to appreciably lower their specific gravity in order to produce a light-weight alloy. Rubidium and beryllium, both having specific gravities of from 1.5 to 1.7, are too expensive to be of any commercial value at the present time. The last-mentioned metal has many qualities which would make it a desirable one for aerial work, but the ores of this metal do not occur in sufficient quantities to justify the prophecy that it will ever be used as extensively as aluminium, although this latter metal only a comparatively few years ago also was very expensive. It is, therefore, likely that nearly all investigations relating to light-weight alloys will continue to be based on combinations of magnesium and aluminium with small percentages of heavier common metals.

* Abstract from an article in *The Foundry*.

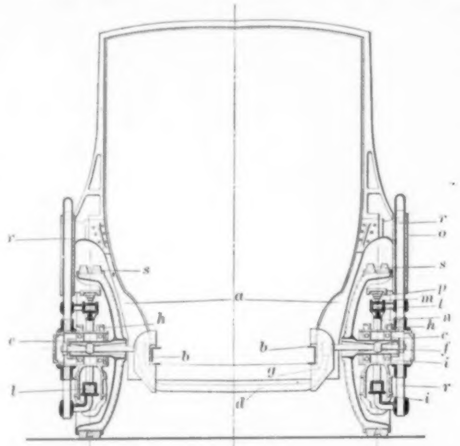


Fig. 1.—THE HEILMANN SUSPENSION

Vertical Section in Plane of Rear Axle

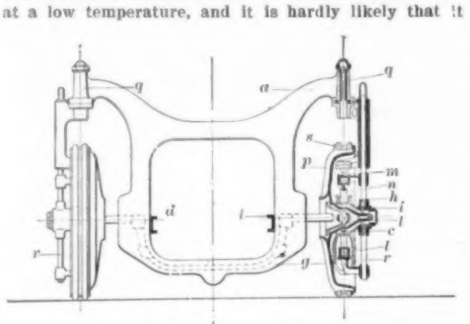


Fig. 2.—THE HEILMANN SUSPENSION.

Vertical Section in Plane of Front Axle

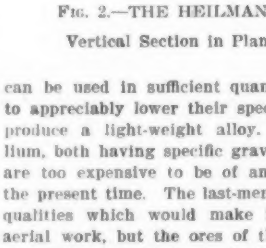


Fig. 3.—Side Elevation

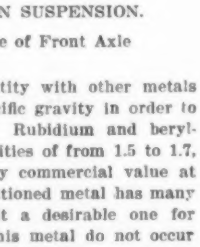


Fig. 4.—Front Elevation

HEILMANN STEERING GEAR

Greek Marble

With reference to the architectural glories of classic antiquity, it may be said that two special advantages came to the aid of the artist's genius and the skill of the constructor. These were superior climate and super-excellent material. It has been pointed out that, were it not for the perfection of their marbles, it is questionable whether even the fine climate of the Mediterranean would have stimulated the architects of Greece and of Rome to create almost imperishable constructions, to be objects of admiration and attempted imitation in our own day; and it remains a curious fact that we moderns still have to turn to the quarries of classic times for statuary marble, while, it has been contended only Greece can yet supply the finest marbles for constructive purposes.

During the fifteen hundred years that followed the destruction of Greek independence, art culture practically disappeared from the land. While the Moors of Spain were patrons alike of art and learning, and saved much of the science and many of the literary masterpieces of classic times from destruction, the Turk seems to have been too busy with the scimitar to have encouraged any arts but those pertaining to the comfort of the governing classes.

The famous marble quarries of the Penteliken, near Athens, remained, therefore, undisturbed and silent until the last century, when, after the coronation of the first King of Greece, the erection of a royal palace again called attention to the national wealth in the finest of stone. The road to the foot of the Penteli hills was reopened, the bridges repaired, and a large quantity of the famous old marble employed in the construction of a new Athens.

It was wisely decided that the old Greek quarries should remain untouched, so that we have clear evidence of the mode of working these in other times. Although the layers are not horizontal, but are dipping inward, the blocks have all been cut and removed by wedges horizontally to the vertical smoothly-chiseled walls. The quarries form therefore a series of gallery-like right-angle stone chambers, from which perfectly regular parallelopipedic stone blocks of every size, even to the largest, were taken, as the thickness of the layers had not to be considered in this manner of extraction.

As the modern system is, however, to prevent diagonal stratification, and also to avoid the more readily weathered seams of mica shale, the marble is preferably quarried from its natural layer. This Pentelikon marble forms a great part of the ranges, and, fortunately, the upper portion. The lower part up to five hundred and fifty feet is limestone in transition; but thence up to eleven hundred feet it is pure marble.

The Pentelikon marble is harder, has a finer grain, and is said to be in every respect superior to the much-vaunted Carrara marble of Italy.

Greece not only supplies the Pentelikon pure white marble, accepted as the best of building stones, but furnishes also fine black and yellow marbles. Then, too, there is the beautiful *Rosso-Antico*, presenting streaks of blood and fire in a broad belt, as well as the *Verdi-Antico*, from one of the islands, with its beautiful mottled varieties.

Model of a Detached Escapment for Pendulum Clocks.

Mr. A. Mallock exhibited, at the recent soirée of the Royal Society, a model of a detached escapement for pendulum clocks, which also illustrates a simple method of keeping the density of the air surrounding a pendulum constant. The pendulum is free in the sense that during the swing it makes no intermittent contacts with any solid. Near the end of each swing an electric contact is made by a fine wire dipping in a mercury cup. The current then established passes through the coils of an electromagnet which, by means of a "remontoir" working a reciprocating lever, causes a very weak spring to act so as to maintain the oscillation. Constant density in the air surrounding the pendulum is approximately secured by the covering bell glass, whose edge dips in a deep but narrow annular canal, partly filled with mercury. An alteration of one inch in the height of the barometer alters the density of the inclosed air by about one part in a thousand.

Electric Lamps and Wireless Telegraphy

There is reported in Germany a curious instance of the capture of a wireless telegraph message by an electric lamp. An inhabitant of Brunswick, who had such a lamp in his laboratory, was surprised to observe that its brilliancy varied with the unmistakable rhythm of Morse signals. Not only did the light vary, but the sounds always given forth by the arc of the lamp varied in consonance. With a little attention he was able to decipher a message which was being sent out from a radio-telegraphic station three kilomters—nearly two miles—away.

The Electrolytic System of Amalgamating Gold Ores*

The Electro-chemist in the Mine

By Elmer Ellsworth Carey

THE increasing demand for gold has turned the attention of miners and metallurgists to new fields and new methods, and every year brings down the cost of mining and milling; new extraction methods are being tried, and every effort is being made to save values in low grade and refractory ores. The tailing piles of yesterday are now being reworked; and to-morrow the tailings piles of to-day will yield further values, as the march of progress discloses new methods, systems and appliances.

The favorite ore of the miner is the so-called "free milling." In such ore the gold particles are comparatively large, and are generally imbedded in quartz ore, free from sulphur, arsenic, etc. Values in such silicious ores may be recovered by the standard system of amalgamation. Then there are other ores where crystals of iron pyrites (sulphides) are found in the quartz, and within the pyritic crystals may be found gold particles in a finely divided state. The values in such crystals cannot be recovered on the usual mill plate, as the particles of gold are coated with various substances, preventing amalgamation. The present practice is to separate the pyritic crystals from the crushed ore by various types of concentrating tables. This so-called concentrate is then sent to a smelter, or it is ground in tube mills (100-200) mesh and delivered to the cyanide tank, where the extraction ranges from 85 to 96 per cent.

Concentrates can only be sent to a smelter where the values are high enough to pay transportation and reduction charges; the cyanide process is expensive and unsatisfactory, unless we admit Mr. Clancy's claim that he has solved the cyanide problems by his system of electrochemical cyanidation.

Another method calls for fine grinding (100 mesh) and electro-amalgamation. An ideal plant for this process consists of some type of rotary crusher, with outside screening, possibly a secondary crushing device to finish the work of the first crusher, and from the crusher the pulp, ground sufficiently fine to release all economic values, is passed over electrolytic amalgamating devices. The released values are recovered in the form of amalgam. Concentration, cyanidation and smelting are unnecessary and the metallurgy of gold is reduced to its lowest terms.

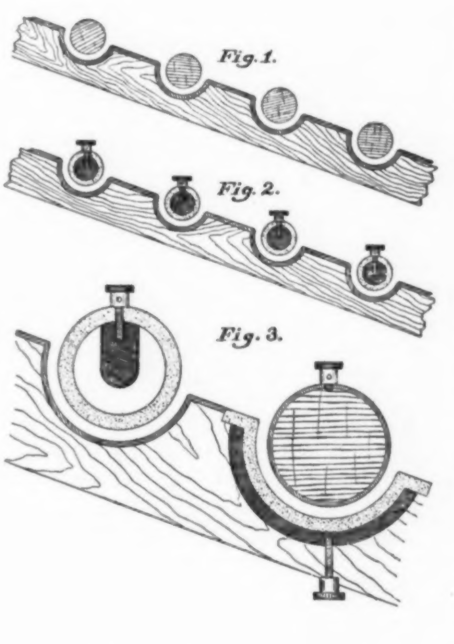
The theory of electrochemical amalgamation has been before the mining world for half a century; one of the earliest authoritative papers on the subject may be found on p. 205 of Vol. I. of the "Proceedings of the (London) Institution of Mining and Metallurgy." Early investigators found as many difficulties as the pioneers in the art of aviation. With no information, no reserve of text-book knowledge, no authorities to consult, no works on electrochemistry, it is not strange that the electrolytic method of gold recovery made slow progress. All the problems of current density, anode troubles, forms of construction, etc., had to be laboriously and expensively worked out. To obtain working data regarding the system will cost an independent observer several thousand dollars and a year or two of time; beside he will draw heavily on his stock of good nature, patience and perseverance.

In electrolytic amalgamation, the sole function of the electric current is to deposit hydrogen, sodium, potassium or ammonia in the mercury. The sole function of sodium or potassium is to de-oxidize water, and the final work in the chain of reactions is the liberation of nascent hydrogen at the surface of the mercury. As the particles of gold sweep over the electrolytically excited mercurial surface, all substances usually preventing amalgamation are automatically and almost instantly destroyed or rendered inert. Grease is saponified by the caustic soda; oxide coating on gold particles is reduced by hydrogen; in a word, gold particles are cleaned and amalgamation quickly follows.

It has been known for some decades that in some way amalgamation was intensified in the presence of the electric current; the problem was to devise a machine to utilize the electrical action to the best advantage. Many complicated devices for this purpose have been patented, but as is usually the case, the successful apparatus is simple—almost childishly simple. So simple is the device that extracts all released values, and so broad are the claims made for it, that the builders of our metallurgical temple have persistently rejected this stone. I will follow the scriptural allusion no farther, but I earnestly suggest that in dealing with any difficult extraction problem, the claims of electro-amalgamation be considered.

Hungarian mercury wells are described in Vol. II. of Prof. R. H. Richards' work on ore dressing; by making the baffle in such wells an anode, using suitable material, and employing an 8 to 12-volt current of high amperage, we have an electrolytic amalgamating device. The objections to the use of such mercury wells disappear when they are electrified, and their extraction efficiency is greatly increased. The interior of such wells must be lined with some very refractory substances. The ideal amalgamator provides a method by which the gangue is brought closely and intimately into contact with a mercurial surface, which acts as a cathode; provide these conditions, and arrange for suitable capacity and durability, etc., and the low grade and refractory ores of the West soon yield their gold.

To-day the mining industry is at a standstill because new conditions call for new methods. The old style mining engineer must give way to the metallurgical and chemical engineer. There are no problems in metallurgy that cannot be solved by the application of the proper electrochemical principles. Electrochemistry has devised profitable methods of extracting the useful metals from other ores, and electrochemistry will also find methods for releasing the



noble metals from Nature's refractory grasp. There is more gold in the West than has been mined; lying in plain view in tailing piles, low grade veins, desert sands, beach and river deposits of the West, there is sufficient gold awaiting the electrochemical engineer to pay the combined national debts of the world. There will be no great advance in the mining industry until the technical schools have furnished a supply of electrochemical metallurgists; for the problems of the mining industry to-day can only be finally solved by the electrometallurgist.

Mr. Clancy has spoken rather disparagingly of the electrolytic system of gold recovery. He says: "One of the most severe criticisms on electrolytic processes is where the direct precipitation of the values from the ore pulp is concerned, the objections probably being due to the scouring of the plates by the circulating ore and the consequent loss of finely divided gold amalgam in the ore pulp."

With the use of the electrolytic sodium-mercury cells, as above mentioned, there is no scouring of the plates, and no loss of finely divided gold amalgam; on the contrary, mill pulp after passing the electrolytic sluices, contains only encased values. The aqua-regia test shows no free values. It is true that the electrolytic plate amalgamation, to be successful, requires considerable experience in the art, but it is possible to arrange electrolytically excited amalgam plates so that the dire results mentioned by Mr. Clancy do not occur. Electrolytic amalgamation will give extraction results equal to electrolytic cyanidation; and when cost of installation, operation and maintenance is considered, all comparison ceases. Scores of investigators in the last twenty-five years have given testimony as to the efficiency of electrochemical cyanidation; the method of regenerating the cyanide solution and the recovery of values not amenable to straight cyanidation have frequently been referred to in the technical and mining journals. Mr. Clancy deserves credit for calling attention anew to the utility of electrolytic lixiviation, and his standing is such that many engineers will doubtless turn their attention to electrolytic process. However, I regret that Mr. Clancy should have found it necessary to disparage electro-amalgamation, which is now slowly being recognized by progressive mining engineers as an important factor in milling. But let no one imagine that he can run a few wires from a power line into a solution tank and have a successful electrolytic cyanide plant; and let no one imagine that he can connect his battery plates with a low voltage generator and thereby greatly increase the extraction. This would be on a par with the village mechanic who purchased working drawings of an aeroplane and set out to build a flying machine.

A simple but very interesting experiment which may throw some light on the wonderful activity of hydrogen-sodium amalgam and the value of electrolytic amalgamation is made by placing a piece of plastic sodium amalgam the size of a pea in a test tube and adding an ounce of water heavily saturated with ammonium chloride. Test the amalgamating powers of the very curious resultant amalgam by copper and iron wire.

Those who wish to investigate the records of the Patent Office for progress in electrolytic amalgamation will find the various types of electric amalgamators described in the following United States patents

626,099	579,211	592,793	418,134	370,366
492,711	669,058	548,265	307,081	285,523
641,360	590,524	328,532	757,557	497,958

DESCRIPTION OF APPARATUS.

An electrolytic amalgamating apparatus should be so constructed that there is a constant and regular electro-deposition of sodium (or some similar element) in the mercury, and provision must be made for passing auriferous pulp or sand over the mercurial surface, so that every particle of gold is forced into intimate contact with the mercury. With the automatic deposition of sodium, and suitable mercurial contact, no free values can possibly escape; and the ideal milling plant of the future will consist of some type of rotary crusher producing a 100-mesh product, followed by a series of electrolytic amalgamators. Such an arrangement will extract all values shown by any free gold test.

The ideal electrolytic amalgamator consists of a series of electrolytic sodium-mercury cells, followed by another electrolytic amalgamating device in which the values are recovered on silver-plated copper plates, of suitable construction. With the mercury wells, high amperage may be employed, liberating large volumes of hydrogen, which removes all coatings (oxides, sulphides, grease, talc, silicious coatings, etc.) from the microscopic gold particles; in the secondary amalgamator the plates offer a large cathode area so that all portions of the pulp are forced into contact with a highly active mercury surface. The supplementary amalgamating device above mentioned consists of a silvered copper plate of suitable width; this plate contains parallel, transverse, semi-cylindrical depressions (grooves, pockets or riffles) the full width of the plate; into these grooves project cylindrical terra cotta cylinders, leaving a quarter-inch clearance, from three to four inches in diameter; these cylinders contain a graphite core, one inch in diameter, connected as an anode.

The pulp passes under the cylinders, and sweeps gently over the curved (cathode) amalgam plate, while gravity, the force of the water and centrifugal force tend to drag each gold particle into contact with the highly excited mercury surface. With such a series of amalgamating riffles, supplied with a low voltage current of proper density, we have an amalgamating device of wonderful activity. It is not too much to say that this simple device will extract 99 per cent of the values which may be saved by any system of lixiviation, the cost of extraction being insignificant.

Fig. 1 shows a section of a new type of mill plate which I have devised. The sides are not represented. The silver-plated copper plate (being of the usual length of amalgamating plates) contains transverse parallel semi-cylindrical grooves into which fit solid cylindrical wooden baffles; these baffles may also be made of standard piping or casing, from three to four

* Paper read before the American Electrochemical Society.

inches in diameter, with the ends closed. The clearance between the plates and the baffles is from three-sixteenth to one-quarter inch. One piece of copper plate may be used, with the proper depressions pressed therein, or, preferably, a number of overlapping plates may be used, each plate containing one or two semi-cylindrical depressions. The plates are held in position by their own weight, fitting closely to the sides, and can be quickly removed from the device for cleaning up. The device may be given any desired grade, and the plates are dressed and operated as the usual mill plate. A mill plate arranged as described will make a better extraction on the average ore than the usual type of amalgam plate, there being no loss of amalgam.

In Fig. 2 is illustrated an electrolytic mill plate, constructed similarly to the one shown in Fig. 2, which will not only recover all values saved by the standard types, but in addition, all free values in silicious pulp and slimes, all values in placer material, beach-sand and all black-sand values are also recovered. The cylindrical baffles are made of terra cotta, and each contains a graphite core connected to the positive lead of a low voltage generator; the amalgam plates are connected to the negative lead of the generator.

In the first groove or riffle shown in Fig. 3 the water and pulp passes over the amalgam plate as in Fig. 2; in the second riffle of Fig. 3, the amalgam plate connected to the negative lead forms a casing for the baffle, and the pulp stream passes *under* the mercurial surface, thus bringing the surface of the water into intimate contact with the electrically excited mercurial surface; or a copper cylinder, silver plated, may be used as a baffle, and at the same time act as an amalgamating surface. A gold saving device may consist of a series of such riffles as shown in Fig. 3, arranged alternately, such an arrangement is particularly useful in treating pulp containing gold in a finely divided form, or for recovering values in slimes or in solutions. By screening placer material to 10 or 12 mesh, and passing the under-size over an electrolytic amalgamating sluiceway of suitable length, all fine, rusty, float, coated and greasy gold is recovered.

With the standard system of mill-plate amalgamation, many difficulties are encountered; with the device just outlined, all the usual amalgamation troubles disappear. The plates may be dressed by hand in the usual manner once a day; by adding a mercuric solution to the water, the proper amount of mercury will be deposited electrolytically to keep the plates in excellent condition. Electrolytic sodium amalgam containing gold is soft, yet tenacious; it is plastic and arrests every particle of passing gold, yet such amalgam never crumbles. Such an apparatus will extract free gold from material having any kind of gangue, clayey, sulphurous, arsenious, etc., and there is no fouling, no formation of sulphide coatings, no discoloration by tellurides, arsenides, etc.

In certain classes of base ores it may be necessary as a preliminary measure to treat the pulp for 30 minutes by electrolytic pan amalgamation before passing the pulp over the electric sluice; and for ores containing gold in chemical combinations (sulpho-tellurides, etc) a preliminary roasting may be required.

In the near future we may look for a greatly increased production of gold, due to the application of electrochemical methods in mining and milling operations; were electro-amalgamation and electro-cyanidation to-day in general use in other mills now in operation, the gross output of gold would be increased 25 per cent. The great increase in the future supply of gold, however, will come from vast low-grade deposits and ledges which cannot now be economically mined. A new field containing fabulous treasures awaits the command of the modern Aladdin—the electrochemical engineer.

Proposed Applications of Electric Ship Propulsion*

The Explanation of New Designs

By W. L. R. Emmet

The writer has published a previous paper on the subject of electric ship propulsion and has, in that and elsewhere, given out a good deal of information concerning designs which have been prepared. The purpose of this paper is to describe some of the newest designs of this kind which have been made and to explain some of their features more fully so that their merits may be intelligently considered by engineers who may be interested.

The use of electric motors to propel ships may at first seem inappropriate since with such a method the power of steam must first be converted into mechanical work, then into electricity, and then again back into mechanical work. All of these processes involve appreciable percentages of loss which seem to discourage the undertaking, and it is only by the most careful scrutiny of all features that the relative desirability of such an undertaking can be ascertained. Some of the important reasons for the adoption of electricity may, however, be suggested by the following comparative figures:

	Revolutions per Minute.	Weight, Lbs. per Horse-power.	Rankine Efficiency.
12,000 kw. high speed turbine without generator....	1200	8.5	71%
Group of Parsons marine turbines, designed to give 28,000 horse-power to four propeller shafts......	325	42.0	......
North Dakota turbines, two, each 13,000 horse-power	300	.. ..	56%

The large differences shown by these figures are incident to speed, the ship turbine being very large, complicated and expensive, and relatively inefficient, while the high speed machine is very simple in construction, small, and highly efficient. It is therefore primarily for the sake of speed reduction that we turn to electricity as a propelling force.

It has also been proposed to use mechanical gearing for the same purpose, and something has already been accomplished in that direction. The use of gearing for such a purpose is, however, still practically undeveloped and the requirements are such that the extent of its application is still entirely problematical. In the case of electric propulsion no such uncertainty exists. We have proved by application to other arts that certain results can be accomplished in a thoroughly reliable manner, and the designs here discussed simply deal with cases comparable with the simplest and most direct uses of electric power on shore.

The comparison of weights and efficiencies of turbines shown by the figures given above apply only to certain conditions and in other cases the comparison might be very different, so that in such a problem every case must be considered on its merits, and its merits cannot be judged until all features of design and operation are worked out in detail. An idea of the requirements of ship propulsion may be given by the following rough statement of conditions:

The power required varies approximately in proportion to the cube of the ship's speed. The speed of revolution of shafts must be suited to the power delivered and the speed of the vessel if good efficiency is to be obtained. There is much difference of opinion concerning the possible relations of propeller speed and efficiency. The following figures gives an estimate of propulsive coefficients of a large battleship. These figures are ascertained by comparison of several sources of information and should be considered only as a rough approximation.

In all vessels quick stopping and reversal is of great practical value, and this quality is particularly valuable in warships. The effectiveness of reversal is dependent both upon the area of propeller blades and upon the torque available for reversal of propellers, so that the requirements of reversal afford an additional reason for desiring low propeller speed, the area of low speed propellers being larger, the tendency to slip is diminished. In some turbine ships, a good deal has been sacrificed for the sake of quickness of reversal and the qualities of different ships in this respect are very different. It may be said that with fairly large and low-speed propellers, a reversing torque equal to 60 per cent of full load running torque will bring a ship up to the best standards of quickness in reversing.

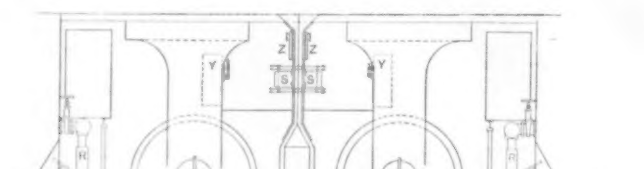
Since practical propeller speeds are always much slower than desirable for turbines, the tendency is to operate marine turbines at speeds below their best point of performance and consequently their efficiency falls off very rapidly with further diminutions of speed. In an electrically propelled ship an excess speed condition can be adopted for the maximum revolutions so that the loss of efficiency with diminishing speeds is relatively less.

Propulsive Coefficients.

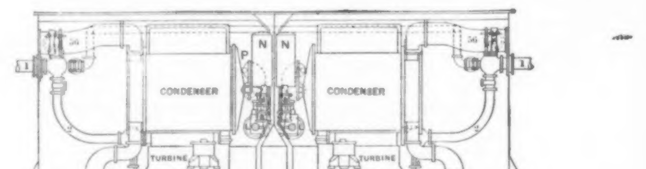
Revolutions per Minute.	Two Propellers.
100	0.56
150	0.532
200	0.507
250	0.485
300	0.470

One of the important advantages of electric propulsion as compared with other possible methods of speed reduction lies in the fact that arrangements can be made by which the ratio of the reduction is changeable so that the turbine may be run at its most effective speed under more than one condition of the vessel's operation. The possibility of such a change in speed ratio is particularly valuable in connection with warships since such vessels need very high speed for emergency conditions and also need to operate economically at low speed so that their radius of action may be made as wide as possible with a minimum dependence upon coaling stations. It will be seen that these qualities cannot well be combined in a ship whose propellers are driven directly by turbines, even if she is equipped with special turbines for cruising conditions. The importance of high speed being much greater in turbines of small capacity than in large, the cruising turbines which require only a small capacity cannot be made efficient.

In this paper some specific information is given concerning two cases of electric propulsion designs. One of these relates to the apparatus covered by a proposition recently made to the government for propelling machinery for Battleship No. 35. The other applies to the machinery covered by propositions recently submitted to shipbuilders for propelling machinery to be used in one of the government colliers recently authorized by Congress. The first of these cases be-



SECTION AT FRAME 104 LOOKING FORWARD



SECTION AT FRAME 89 LOOKING AFT

Turbine electric propelling apparatus installed in engine-room of battleship with all auxiliaries specified for direct turbine installation.

* Presented at the Pittsfield-Schenectady mid-year convention of the American Institute of the Electrical Engineers, Feb. 1911. Copyright 1911, by A. I. E. E.

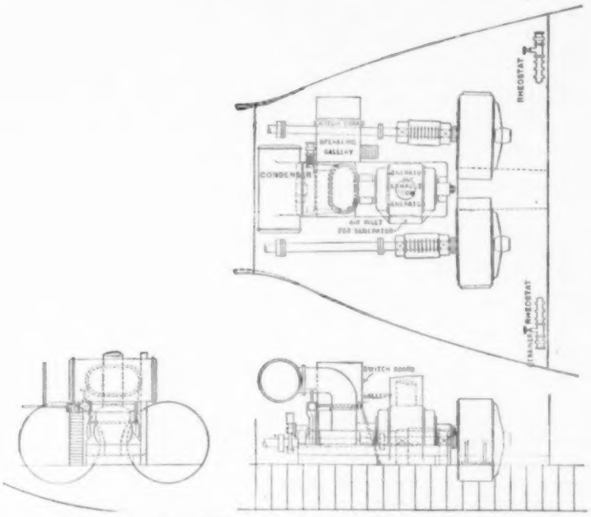
ing that of a high speed warship, the arrangement has been made such that two ratios of speed reduction could be used, the change from one to the other being accomplished by changes of connection which accomplish a change in the number of poles of the propelling motor. In the second case no such pole changing is used, the ratio between turbine and propeller being fixed at all speeds.

In the battleship, two generating units and four motors are used so that an additional gain in economy can be effected at all speed by operating with one half of the apparatus in use. In the case of the collier there is only one generating unit and two motors so that all the apparatus is used at all speeds. In the case of the collier, however, the speed conditions are very favorable to the turbine and the speed efficiency curve is extremely flat as compared with that of turbines generally used for direct propulsion of ships.

DESIGN MADE FOR UNITED STATES BATTLESHIP NO. 35.

The installation proposed for Battleship No. 35 is shown by the accompanying drawing, which shows not only the electric generating and transmission apparatus, but all the auxiliaries which are installed in the engine room in the government designs for direct turbine drive. The position of shafts and arrangement of engine room in this case is identically the same as that proposed by the government for direct drive by Curtis turbines. The apparatus is installed in two engine rooms, separated by a water-tight bulkhead. In each engine room would be installed one 12,000-kilowatt generating unit and two motors, each having a capacity of about 7,000 horse-power. These two motors are coupled together into a single unit and connected to the propeller shaft. One of these motors is of the K type with squirrel-cage armature, the stator windings being so arranged that they can be connected either for 30 or for 50 poles, a suitable group of heavy toggle switches which effects this pole-changing being carried by the frame of the motor itself. The other motor is of the M type with a definitely-wound rotor connected to slip rings through which an external resistance can be inserted in series. These slip rings are short circuited by a very simple and effective sliding spring arrangement. When this short circuit is accomplished the external resistance is entirely cut out. This M motor is wound for 30 poles, and with its resistance cut out has exactly the same characteristics as the K motor when the latter is worked with its 30-pole connection.

The resistance used with the type M motor is for the purpose of affording the desired torque in reversing, and these resistances constitute a very important feature of the proposed designs since under conditions of reversal they must absorb nearly the total electrical energy of the system. These resistances have been developed by careful experimenting and are capable of accomplishing the desired result in a very compact space and with very large factors of safety. They are made of non-corrosive material and the heat from the electrical energy dissipated is delivered to the sea water which freely circulates through the resistance compartments by convection. They are easily disconnected and taken apart, or, if desirable, renewed, and will afford an entirely satisfactory solution of a problem which has sometimes been very embarrassing in large induction motor installations. The accompanying drawing shows the arrangement of these resistances in sufficient detail to be intelligible.

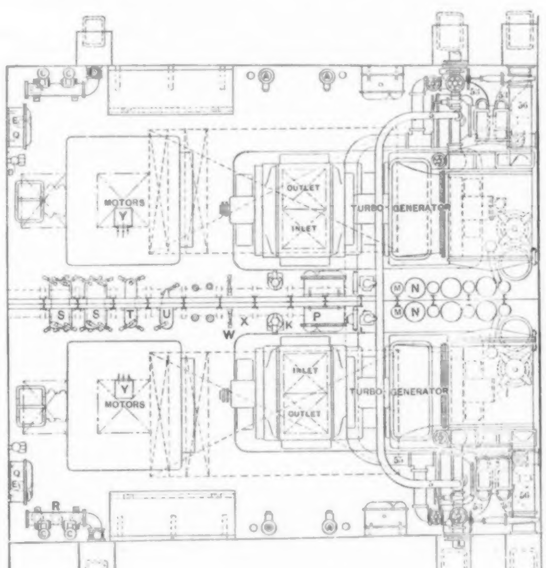


TURBINE ELECTRIC PROPELLING APPARATUS

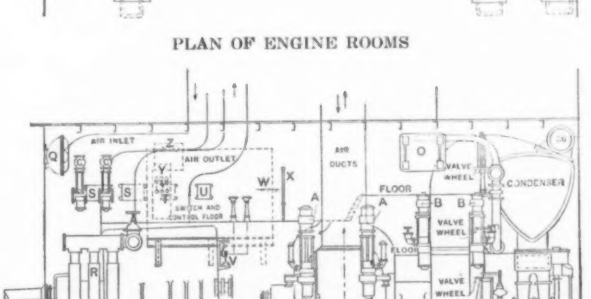
Installed in engine-room of Collier with condenser but no other steam auxiliaries shown.

The switching apparatus is so arranged that all switches can be worked from either engine room, the shafts being carried through bushings in the water-tight bulkhead. When the ship is operated at high speed with both generating units the engine rooms will be operated separately, but when the ship is operated from one generating unit it will be more convenient to control everything from one engine room, and the switches are so arranged that this can be done, the position of every connection being visible and controllable from either side of the bulkhead. The accompanying tabulation and curve sheet shows the propeller speed, horse-power, and water rate of turbines for every different speed of the ship, and shows the apparatus which would normally be in use under each condition of speed.

The conditions for different speeds are those which will give the best economy and which would ordinarily be used for continuous operation at such speeds, but it is possible to vary the speed of the ship up and down with any arrangement of motors by simply changing the steam admission to the turbines, the only limit being the safe speed and safe carrying capacity of the apparatus. Normally the ship would be operated at higher speeds with two generators and four motors, all of the motors having the 30-pole connection. The turbine speed is then reduced in the ratio of 7.5 to 1, the generators having four poles. When the speed becomes sufficiently reduced improvement of economy can be effected by disconnecting one

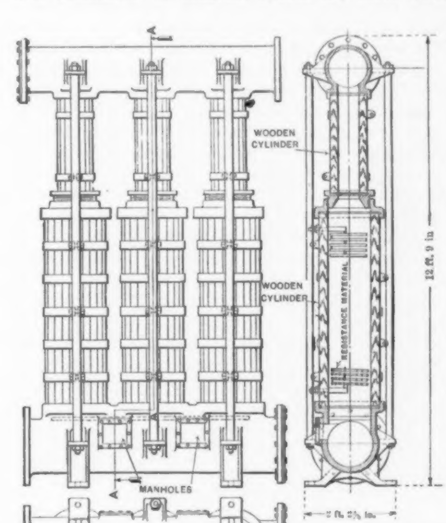


PLAN OF ENGINE ROOMS



ELEVATION OF STARBOARD MACHINERY LOOKING INBOARD

A, Main feed pumps; B, Fire and bilge pumps; C, Forced lubrication service pumps; D, Fuel oil pumps; E, Oil cooler circulating pumps; F, Pipe insulator circulating pumps; K, Auxiliary air pumps; L, Auxiliary circulating pumps; M, Air compressors; N, Compressed air tanks; O, Feed heaters; P, Auxiliary condensers; Q, Oil coolers; R, Water rheostat; S, Motor switches; T, Generator switches; U, Tie switch; V, Pole-changing switches; W, Hydraulic gear operating wheels; X, Liquid tachometer; Y, Field rheostat; Z, Switch panel.



GROUP OF RESISTANCES FOR 7,500-HORSE-POWER MOTOR FOR BATTLESHIP EQUIPMENT

of the generators and two of the motors as shown by the curve, and when the speed had fallen sufficiently low a still further gain can be accomplished by connecting the remaining motors for 50 poles instead of 30 poles. When this change is made the ratio of reduction is increased from 7.5 to 1 to 12.5 to 1, and a new cycle of favorable speed operation in the turbine is begun. The economy in speeds between 12 and 14 knots is of vital importance in war ships, and the very fine economy under these conditions afforded by this design will immensely increase the military value of a vessel so equipped.

TABLE I.

Steam conditions—265 lbs. pressure, vacuum 28 inches, 50 deg. F. superheat.

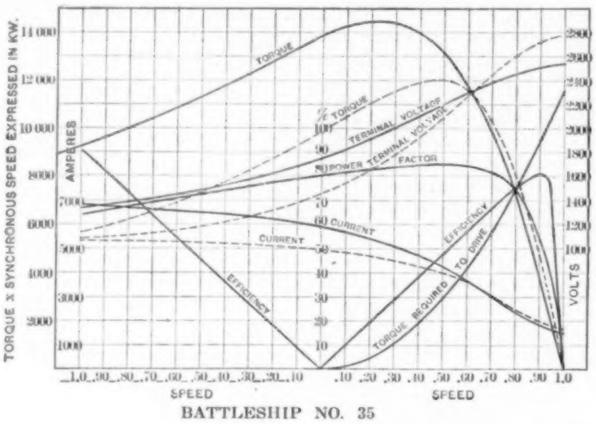
Knots	12	16	18	19	20	21
Motor speed	87	117	132	140	149	160
Generator speed	1110	895	1010	1072	1140	1120
Shaft brake horse-power	4630	11100	16400	19400	23100	29000
Lb. Steam per shaft horse-power	13.2	13.4	11.8	11.3	11.25	11.3

Since the power required to propel a ship falls rapidly with diminished speed, and since it is not necessary to maintain any fixed frequency, voltage, or degree of excitation, the magnetic densities of the apparatus can be varied as the speed reduces so as to give the best efficiency consistent with the torque required. With such an equipment the excitation could be derived either from an outside source or partly from an outside source and partly from a direct-coupled exciter. In this case it is proposed to excite from an outside source—the ship's regular circuit—but this excitation can be varied by a rheostat so that the best possible electric efficiency is maintained.

In the installation here described it is proposed to ventilate the apparatus by air from the upper deck. One duct will convey air to each piece of apparatus and another will discharge it outside the engine room, the apparatus being so designed as to impel the proper amount of air through these ducts. In this and other cases of electric ship propulsion, it might be desirable to ventilate the apparatus by drawing air through it by blowers and delivering the air so heated to the furnaces. Such a process would effect appreciable economy and would probably be desirable. It has not been considered in this case because there was not time to study the practicability of arrangements.

In this battleship installation it is not proposed to make any changes of connection of circuits, resistances, or poles while the current is flowing. Preliminary to all such operations the field switch will be opened. The switches proposed are of the toggle type, not designed to open under load, and are arranged with electric locks so that they cannot be moved when the system is alive. The turbines are arranged with speed governors of the ordinary type which are capable of closing any valves which may be open if the speed rises. The number of valves which can be opened at any time is, however, governed by hand control, and the speed governor is incapable of adding to the number so opened. When the field circuit is interrupted the generating unit rises to its maximum speed and runs idle until the circuit is re-established. In the meantime the desired connections are made and the field re-established, whereupon the generator and motors resume the proper speed relation and proceed to accomplish the desired result.

When these electrical conditions are considered it would simply be necessary to open the field circuit and change to the proper connection, and the currents resulting from such wrong connections would not be harmful since the mistake would be apparent and soon corrected. The case is therefore very different



BATTLESHIP NO. 35

Conditions of combined operation of motors and generators and reversing resistance in circuit and generators at full speed. Dotted lines show torque, voltage, and current when only one generator is used. The power factors and electrical efficiencies are about the same with either one or two generators. External resistance 0.207 ohm per phase, rotor resistance 0.0069 ohm per phase.

from that of an ordinary electric circuit where all sorts of needs must be provided for from a source of fixed potential and where the generating plant constitutes a battery capable of delivering power in indefinite quantities, either for use or for destruction in the case of short circuits or wrong connections.

The following is a list of the weights of the different parts of the installation proposed. The aggregate weight of these parts is probably not much less than that of the turbines alone which would be used for direct propulsion. The generating units in this case, however, include heavy cast iron bases, and there would be a considerable saving on account of the supporting structures which would be used with turbines for direct propulsion. The absence of any system of forced ventilation also increases the weights. In other cases of battleship propulsion which have been studied, considerable savings of weight have been effected, and it is believed that with the best arrangements, similar economies could be accomplished in this case.

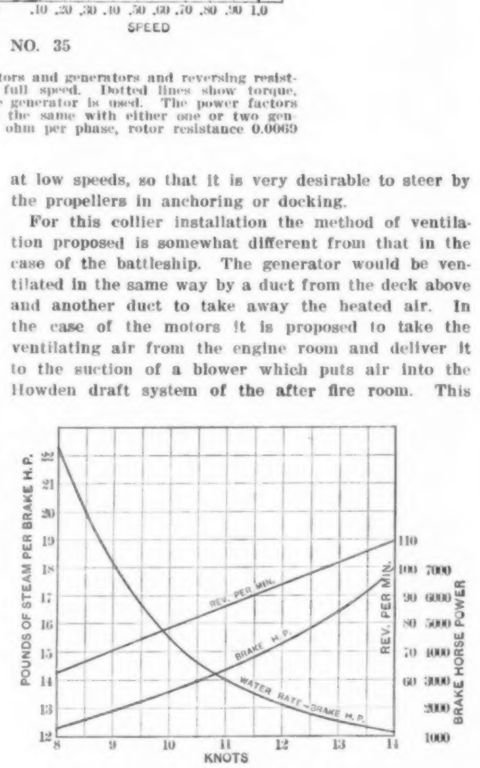
	Pounds.
Two generating units	674,000
Accessories	2,600
Four motors	408,000
Switchboard and switches	5,000
Field rheostats	1,600
Water-cooled rheostats	6,000
Cables	17,800
Total weight	1,115,000

EQUIPMENT FOR NAVAL COLLIER.

The installation proposed for a naval collier is similar in general principle but much simpler than that proposed for the battleship. The requirements of this ship being to operate continuously for long periods at a speed near the maximum, there is no particular need for high economy at lower speed, and it therefore becomes desirable to simplify the apparatus as much as possible in the interest of lightness, cheapness, and good economy at the normal operating speed of the vessel, which would be about 13 or 14 knots. In this case only one generating unit and two motors are used.

Another difference between this case and that of the battleship is that it is proposed to use oil switches so that changes of connection can be made without the trouble of interrupting the field circuit. When the resistances are in circuit in the motors, either propeller could be reversed independently by simply throwing the lever of an oil switch. This quality of instantaneous reversal would be valuable in a ship of this kind since such large freighters steer very badly at low speeds, so that it is very desirable to steer by the propellers in anchoring or docking.

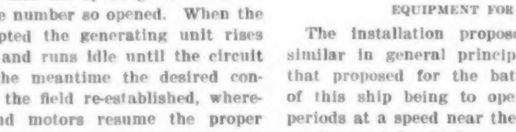
For this collier installation the method of ventilation proposed is somewhat different from that in the case of the battleship. The generator would be ventilated in the same way by a duct from the deck above and another duct to take away the heated air. In the case of the motors it is proposed to take the ventilating air from the engine room and deliver it to the suction of a blower which puts air into the Howden draft system of the after fire room. This would afford effective ventilation for the motors and about the right amount of ventilation in the engine room without the use of any other blowing apparatus.



PERFORMANCE CURVE, ELECTRIC DRIVE, UNITED STATES COLLIER

190 lb. gage; 0 deg. fahr. superheat; 28½ in. vacuum—displacement about 20,000 tons.

The accompanying curve sheet shows the steam consumption per shaft horse-power which would be required with this apparatus at different speeds of the vessel. These results are susceptible of exact calculation since generating units and motors almost exactly similar to those proposed have been repeatedly tested. It is very difficult to get at any accurate estimate of the steam consumption of such a ship when operated by reciprocating engines, but all comparisons which have been made indicate that the turbine electric apparatus would effect some economy in steam consumption, although it is probable that the saving as compared with the best engine equipment would not be very large. The demand for electric propulsion on one of these colliers has come from the Navy Department through a desire to demonstrate the practicability of this method of propulsion. The case is not particularly favorable to electric propulsion and should not be taken as a basis of comparison of the system with other methods. Electric propulsion will make its best showing in vessels requiring a very large amount of power or vessels which require a good economy at low speeds as well as at high. High-speed warships or very large moderate-speed liners afford the best fields for its application.



PERFORMANCE CURVE, UNITED STATES BATTLESHIP NO. 35

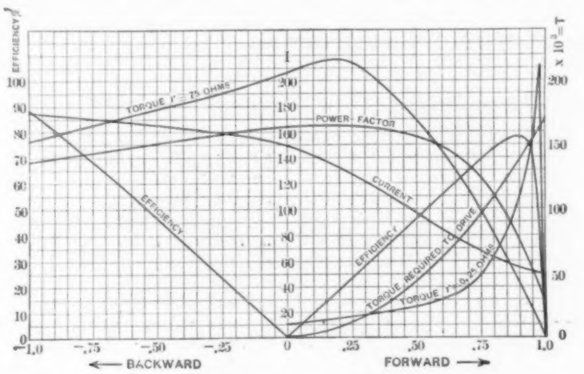
Pressure 265 lb. gage, 50 deg. fahr. superheat, 28 in. vacuum.

will be seen that an immense advantage results from the fact that they are not bound to any fixed frequency or voltage. The generator is designed simply to do the work required of it, and it is incapable of delivering a current in excess of the safe carrying capacity of any conductor in the system. No kind of wrong connections can result in any burn-out. If a wrong connection should be made

ELECTRIC CHARACTERISTICS.

The accompanying curve sheets show the characteristics of the combined action of motors and generators proposed for these two installations. Two of these sheets show conditions of operation or reversal with resistances in circuit, and the other shows the

conditions in the collier installation without resistance in the motor circuits and with the generator operated at various speeds. From these curves the torque available under any condition of operation and also the current, voltage, and necessary excitation can be seen or readily estimated. No curves are given to show the conditions of operation without resistance in the battleship installation because the characteristics under such conditions are virtually the same as those in the collier, and are sufficiently illustrated by the curves given in the case of the collier. These curves shows the effect of different degrees of excitation upon power factor and efficiency. As a vessel so propelled is slowed down, the excitation could be reduced in proportion to the propeller speed and the maximum degree of reduction in excitation will give the best electrical efficiency. From the curves here given, however, the decline of excitation is less rapid than that of the speed, this degree of diminution being chosen so as to give an ample margin of torque under all possible conditions of operation. In practice, whenever the ship is operated under any fixed condition of speed, the excitation should be reduced to the lowest possible point necessary to maintain the required torque on the propeller. Since the margin of torque assumed in the curves given is very ample, the electric efficiencies would be even better than those indicated by the curves.



UNITED STATES COLLIER

Showing conditions of combined action of generator and motors with reversing resistances in circuit and with generator at full speed. External resistance 0.75 ohm per phase, rotor resistance 0.025 ohm per phase.

In connection with this paper which gives specific information concerning two sets of designs, the author has thought it desirable to give also some figures concerning other cases which have been studied with greater or less degrees of thoroughness in order that an idea may be formed regarding the relative desirability of such methods in connection with ships of different kinds. The accompanying tabulation gives some such figures:

TABLE II.

Case.	Displacement, Tons.	Shaft, Horse-Power.	Approx. Wt. Main Engines or Turbines Tons.	Weight of Corresponding Electric Drive.	Speed Knots.	Revolutions per Minute, Electric Drive.	Water Rate Elec. Drive, Without Aux., lb. per Shaft Horse-power.	Steam Conditions.
1	19,360	6,850	335	135	14.0	110	12.0	200 lb. gage, 28.5 vac. dry.
2	25,000	12,500	411	237	16.0	110	11.5	200 lb. gage, 28.5 vac. dry.
3	30,000	3,400	435	374	12.0	87	12.85	260 lb. gage, 28.0 50° superheat
	......	17,300	435	374	20.0	148	11.5	260 lb. gage, 28.0 50° superheat
4	10,945	2,275	102	55	10.5	85	13.0	175 lb. gage, 28.0 dry.
5	9,900	5,500		133	14.6	114	12.5	181 lb. gage, 28.0 dry.

Some of these designs for apparatus to propel ships have been criticised on the ground that the weights of electric apparatus shown were small in comparison with weights of similar kinds of apparatus used on shore. This is to some extent true, first, because the structural part of these devices has been designed with a view to economy of weight, although the designers have not gone nearly as far in this direction as it would be possible to do; and secondly, because this ship apparatus is rated on a maximum output basis, whereas apparatus for other purposes provides for overload. There have been some further weight economies possible on account of the special conditions relating to the operation of such apparatus. A careful comparison with a number of cases where large apparatus of similar character has been installed on shore shows that on a basis of very reasonable temperature rise, the magnetic weights in all cases agree closely and that these electrical designs are in every respect normal and conservative.

A Few Odd Things

It is said that in a room in Pompeii which was covered by Vesuvius' ashes eighteen hundred years ago, the excavators broke into a room full of glass of many kinds, window glass, ground glass, cut glass and many varieties of colored glass, and the Romans claim that they got malleable glass from the Arabians.

Pliny tells of Nero having a ring with a gem in it through which he looked at the gladiators to see them more clearly. Evidently old Nero had a monocular opera glass. Ruskin, in one of his lectures to his students, said, "Gentlemen, we are the best chemists in the world. No Englishman ever could doubt that, but we cannot make such a scarlet as that; and even if we could, it would not last for twenty years, yet this is five hundred years old." Such a dye could certainly be warranted against fading.

Copper Production and Copper Reserves

In his economic studies of the world's supplies of the principal metals, Prof. J. A. Kemp devotes a special section to copper. Speaking of this in *Science*, he says:

"Greatly stimulated by the development of electricity in later years, the production of copper has advanced by leaps and bounds. At present the United States are the heaviest producers, with Spain following next, but only yielding one-eighth as much. The United States furnish over half the total. In 1850 the United States yielded 728 tons; in 1900 over 303,000 and in 1908, 471,000. Meantime, in 1850, the price of copper was about 30 cents per pound. Its lowest point in recent years was nine cents in 1894. Its highest, 25 cents, was attained in 1907. We may each of us imagine the variation in the profits of a mining enterprise as between 11 cents a pound and 15 cents, let alone 20 or 25 cents. Mining costs, smelting and freight charges, show no such variation, so that with rising prices profits greatly increase. Indeed, few of the metals have such ups and downs as does copper.

"In its ores the yield varies greatly. On Lake Superior, where the native metal is distributed through ancient lava flows in little pellets, leaves and sheets, it has been profitably mined and produced through periods of years, when it constituted but three-quarters of 1 per cent of the ore. The general run is, however, 1 per cent and above. If we recall that in a ton of 2,000 pounds 1 per cent is 20 pounds, and three-quarters of 1 per cent 15 pounds, and if copper is selling at, say, 13 cents, the mining manager must break down, hoist, concentrate, with attendant losses, and smelt an ore worth less than $2 for all the metallic contents which it contains. We can thus gain an idea of the close and economical work required and the ability demanded of a manager. As the price rises the profits greatly increase, and temporarily idle mines are brought within the widening remunerative zone, and are quickened into life. As the price falls, the mines dangerously near the line close down and production ceases. The lowest cost of production claimed is from the low grade and very large ore bodies of the West, and is placed at or about 8 to 9 cents per pound laid down in New York.

"In copper ores outside of the Lake Superior region, we usually find the metal in combination with sulphur. The ores as they come from the mine may be rich enough to go directly to the smelter, or they may require concentration before the grade is sufficiently high. The ores which are directly smelted reach the minimum of copper in the boundary district of British Columbia, but associated gold and silver raise the value per ton above $4. Copper ores yielding copper alone were smelted at Ducktown, Tenn., during long campaigns, at a little less than 2.5 per cent. In earlier years and in many mining districts ores as high as 20 per cent were found, rarely even higher, but they in time were exhausted and 5 per cent would be quite rich for day in and day out averages.

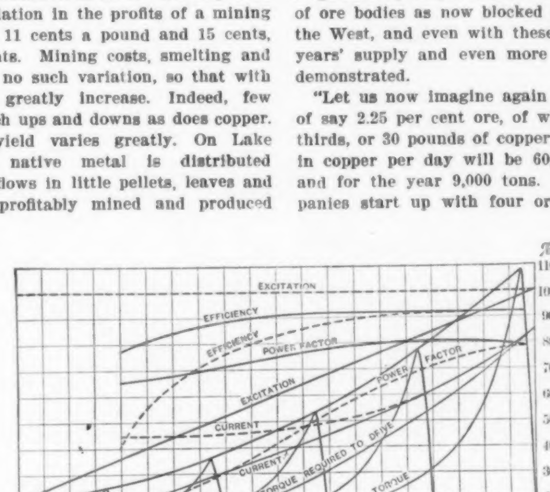
"We can not predict copper with the certainty of iron. It seldom appears in bedded deposits which can be measured. In the deep mines we can not always see ahead for more than a year or two. In some mines we know from exceptionally complete development, of twenty years' supply. But the great advance in copper mining has been the entrance of relatively low-grade ores into the productive field. The wall rocks of ten years ago have become the ores of to-day. Where we find in porphyries or schists copper sulphide disseminated in fine particles or as coatings along crevices, and in sufficient richness to yield 2 to 2½ per cent, throughout very large bodies, it can be mined very cheaply and concentrated in enormous quantities, so as to return a safe margin. If the ore lies near the surface, steam shovels make excavation extremely low in cost. The huge pits and open cuts of this type of mine in the West are now among the great sights for the traveler. Mills whose insatiable crushers take as much as eight or ten thousand tons per day are no longer unknown. The drill blocks out the ore before mining begins, and reserves can be estimated more closely than in the vein mines.

"If a mine is called upon to furnish a mill with 2,000 tons per day and we allow 300 working days in the year, 600,000 tons must be supplied per annum. For a life of twenty years, a time practically demanded of such an enterprise to justify the great expense of installation, at least 12,000,000 tons must be shown by the drill before the enterprise can safely begin. If we expect to mine three times this amount per day we call for three times as much ore. These figures, large as they may seem, are not beyond the estimates of ore bodies as now blocked out in several places in the West, and even with these great demands, twenty years' supply and even more in instances have been demonstrated.

"Let us now imagine again a 2,000-ton daily output of say 2.25 per cent ore, of which the mill saves two-thirds, or 30 pounds of copper in the ton. The output in copper per day will be 60,000 pounds, or 30 tons, and for the year 9,000 tons. Should three new companies start up with four or five times this output, 36,000 to 45,000 tons will be added to a yearly supply, which in 1909 was 552,668 tons. We see great need of a growing demand in order that these vast contributions may be absorbed.

"How long will our copper hold out? For the immediate future there will certainly be no scarcity. Copper does not oxidize as readily as iron and is not lost. The world's stock steadily accumulates. But twenty years is not a long look ahead. Are there new countries which will be producers? Some old mines in Europe are no longer sources of the metal.

"We do know of possibilities in Alaska that will



UNITED STATES COLLIER

Showing condition of combined action of generator and motors with varying speed of generating unit and with no external resistance in rotor circuit. Dotted lines refer to constant full load excitation. Full lines refer to variable excitation. Torque curves of motor are given separately for different fixed generator speeds. All other curves apply to normal conditions where speeds of motors and generators vary together.

add some contributions. We know of new or recently opened ore bodies in Peru, Bolivia and Chile that promise well. We hear of very large deposits in the southeastern corner of the Congo State, once worked by the ancients, now revived by the moderns, and possessing large reserves of 15 per cent copper ore. The Cape to Cairo Railway will give them great impetus. For the immediate future there is no lack, but if we look fifty years or a century ahead we can speak with less confidence. In a general way we may say that probably new discoveries will, for a time at least, more than keep pace with demands. But when we look fifty years into the future we are not so certain. It behooves the producers to use no treatment of an ore except a careful and economical one. If tailings and waste from our mills now contain one-third the copper in the original ore, they should be impounded and kept from being washed away by floods, against the possible call of the future. We dare not say that they will never be within the ranges of profitable treatment, even though their low percentage places the copper beyond reach to-day. The copper situation is not one to excite anxiety, yet it is also one not to encourage extravagance."

The New Rigid Dirigible of the English Navy "N I"

A Giant Airship of Novel Construction

By Carl Dienstbach

THE Zeppelin Airship Construction Company has always firmly refused to build any airships for foreign countries, on the ground that its plant is virtually a gift and a trust of the German nation, that contributed nearly $2,000,000 to Count Zeppelin's enterprise, and that therefore none of the experiences and facilities of the Zeppelin dockyard should inure to the benefit of foreign governments.

By Courtesy of the Illustrated London News.

THE BRITISH NAVAL AIRSHIP "N I": THE FIRST DIRIGIBLE BUILT FOR THE ENGLISH NAVY

In England the authorities have been so severely critised for "trifling" with the serious question of an aerial navy, and merely building a series of pygmy military dirigibles for experimenting and training purposes, that the English people bought by subscription the two latest and best French airships, the big "Clement-Bayard II," and the new gigantic "Lebaudy," and presented them to the government. Patriotic and welcome though this action was, it may be said to have been inspired by a popular misunderstanding of the government's policy. For England the first necessity is a naval dirigible. An airship that must be capable of hovering over the channel fleet's field of action and follow the home fleet far out into the North Sea had not yet been developed abroad, nor could it be created over night. Endurance, staunchness, economy of fuel at high speed, insensibility to weather and sun, were the qualities most desired. The authorities were soon aware that the type perfected by Count Zeppelin and his engineers and pilots came nearest to meeting these requirements, but all endeavors to profit directly from the priceless experience and skill acquired by the Count and his staff during nearly a decade of painstaking labor met with a flat refusal. Nothing remained but to make the experiment unaided, and it must be conceded that the English have approached this task with a deliberateness and thoroughness worthy of its importance. What it really meant may be gathered from the failure of the Schütte-Lanz giant rigid dirigible, whose wooden frame cost hundreds of thousands, and finally became far too heavy. In England a colossal revolving arm or "whirling table" was erected at great expense for the sole purpose of testing the naval airship's propellers under the conditions that prevail in actual flight, and for developing the most economical type.

The English "N I," as the new aerial dreadnought is called, has just been completed after remaining on the stocks for nearly three years. From the "Zeppelins" so far built it differs in the displacement, which exceeds even the big "Deutschland's" by fully 1,000 cubic meters, being 20,000 instead of 19,000. The length is 510 feet, instead of the "Deutschland's" 485½, and the beam 46 feet. Instead of aluminium the new lighter and stronger alloy, duralumin, has been used in the hull.

A noteworthy innovation is found in the engine room. Reliability of the propelling machinery of airships was for a time sought in multiplying the motor units. "Deutschland" and "Z VI" had three motors, the new "Krell I" has four motors. Most recently this tendency has undergone a temporary change. It is now the fashion to install more powerful units, engines that are to all intents and purposes identical with those of the "big gasoliners" of the ocean, and like them are not much given to breaking down. Thus the new German military airship, "M IV," is driven by only two engines, but each of 200 horse-power, and the English "N I," built more for endurance than extreme speed over water, has also two 200 horse-power motors for its greater displacement. In the "M IV" these motors have each six cylinders and are very heavy; the engines of "N I" have eight cylinders each and are built by the firm of Wolseley of heavy gasoline traction frame. As Count Zeppelin's "Deutschland" developed a speed of nearly 38 miles an hour with three motors of 115 horse-power each, the "N I," that has finer lines at the stern, is expected to make 43 miles an hour with 55 horse-power more and only 1,000 cubic meters more displacement—which results solely from increase in length, not of beam.

In still larger airships there will be again multiplication of motor units—to distribute the load—but, each motor being of 200 horse-power, sufficient reliability will also be guaranteed in the single unit. The "N I" is equipped with powerful apparatus for wireless telegraphy.

Copying Process for Printed Matter and Manuscripts

A NEW method for photographic printing was presented to the Académie des Sciences by M. De Fontenay, and it is likely to be of great service in some kinds of work. It is used in reproducing any sort of printed matter or manuscript, such as pages of books or engravings, letters, etc., and these may be even printed or written on both sides. He uses an ordinary printing frame and places in it first a sensitive photographic plate with the glass side outwards and then the printed page, in contact with the emulsion. This is exposed to light in order to make the print. The black parts of the page absorb nearly all of the light, and on the contrary the white portions diffuse the light and reflect it upon the corresponding parts of the sensitive layer. After developing the plate, we have a negative somewhat similar to that which would be given by making a print by transparence in the usual way. The new method exposes the whole of the photographic plate, and the printed page lies back of it, so that the process would seem paradoxical at first, and it would appear that the plate should be fogged. This is not so, as is proved by its development. Any ordinary developer will answer. It is found that the exposure should be made by red light, and green or yellow light also gives good results, but blue and violet do not succeed. Slow plates appear to be the best, and even photographic paper could be used, were it not for the fact that the grain of the paper is apt to spoil the effect. The new method is likely to prove of value. It will render great service where a copy is to be made strictly like the original, with opaque sheets or those having printing on both sides, including book text, engravings, figures bound in a book, parts of maps, and the like. Such are generally copied by the camera, but this is often cumbersome and cannot be used in all libraries. It is also difficult to make a copy in full size, not considering the distortions given by the lens. At present we are able to make copies in any library where darkness can be obtained for a short time so as to allow of putting in the plate, and such copies are very exact. A printing frame is not indispensable, and the sheet can even be applied by the hand. All the outfit that is needed is a few plates and a box of matches, or better, a pocket electric lamp. The archæologist or other worker when traveling and not having a camera at hand can thus very easily secure copies of valuable documents.

Demolishing a Reinforced Concrete Building

Steel Rods in Reinforced Concrete do Not Rust

Our illustrations show a number of views of the operations in progress in the demolition of a seven-story reinforced concrete building at Baltimore. This structure was erected shortly after the great fire of 1904, and is consequently comparatively new, and built on the modern lines of this type of construction.

The massiveness of the building, which was regarded as fireproof, is shown by the fact that some of the larger pillars and girders in the framework weigh no less than one ton to each linear foot. These are 2 feet in thickness and 5 feet in width, and one of the main girders supporting the upper framework is no less than 49 feet long. It is reinforced with 42 steel rods extending entirely through the concrete. Twenty-six of these rods are 2 inches in diameter and sixteen 2½ in diameter. In some parts the thickness of the reinforcement is as much as 3 inches. The total weight of the concrete in the building is estimated at nearly 8,000 tons, not counting brick used in partitions and elsewhere. The floors are of a layer of concrete 2 inches thick, set into a mesh of ¼-inch steel wire, while the stairways are molded of concrete blocks.

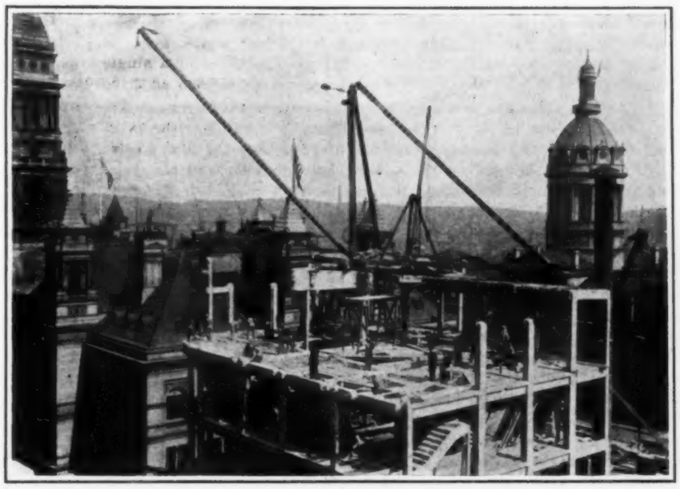
This seven-story building, which has been utilized for newspaper publication, is to be replaced by a sixteen-story office building, and every part, even to the foundation, must be removed. A contract has been concluded to demolish the building in 90 days. Work was commenced in March, and is progressing so rapidly, in spite of the great weight that must be removed, and the difficulty of severing the heavy framework into sections for removal, that during April fully 75 per cent of the building had been torn out and turned into concrete ballast for railways and into scrap steel.

The system employed is notable for its time and labor saving features. Beginning at the top, the roof members had to be cut and burned into sections that could be readily lifted by a boom derrick and lowered by block and tackle to wagons in the street to be hauled away. As much of the concrete work averages 7 tons in weight for a length of 6 feet, the majority of the posts, girders and other material have been separated into this size. The first process is to cut through the concrete. This is done by compressed air hand drills operating at a pressure of 125 pounds to the square inch. The steel point bores into the material, making an opening varying from 6 inches to a foot in width, so that very little debris results. The tool is guided between the steel rods, removing all the concrete until they are completely exposed in the concrete fissure.

The steel is not cut by saw or chisel, but severed by corroding heat. A Linde compressed air coal gas burner is used. Portable reservoirs are filled with gas at a pressure of 1,800 pounds. The burner is connected with tubes for conveying the gas, also oxygen. The flame composed of these elements develops a heat of fully 2,000 degrees. The burner is pressed against the rod until the latter becomes red hot. Then the oxygen is applied to the metal and corrodes it, so that it becomes honeycombed. As the flame is small in dimensions, less than a half-inch of the metal is removed in severing the rod. How rapidly the work is done appears from tests made on the Baltimore building, which show that one man can with the burner do as much as eleven men with saw or chisel in the same time.

In removing the concrete sections, two boom derricks are used. The boom of one is 60 feet long, and from it extends a block and tackle of a capacity to handle any weight which is to be conveyed. When a piece of girder or pillar is ready to be taken out, the end of the boom is swung over it in the usual manner, and the load clamped by chains, when it swings out and down into the wagon. The pieces are taken to a dump yard near a railroad track, where a skull cracker having a drop of 60 feet and a weight of 2,000 pounds crushes the concrete into fragments. It is then loaded on cars for ballasting and the steel is sent to the mill for rerolling.

Considering the operations performed in the work of demolishing, the power plant is comparatively small. The compressed air is supplied by two compressors of 30 horsepower each. The air is forced through iron piping laid in the building, and tapped at several different points with wire-wound flexible hose. Thus the drills are operated for cutting the concrete. An equipment of 40 drills is installed, but 25 have been found sufficient to do the work, the others being held in reserve in case of a tool breaking or becoming full. The burners are connected with metal tanks which one man can carry from place to place, but the tubes connecting the tank with the burner are long enough to allow the operator to separate the metal of a half-dozen sections or more before moving the reservoirs. After the concrete has been cut out there is no time lost. As the air tool finishes its work, the burner takes its place, and such is the rapidity of the action that the largest concrete form may be severed in two places, lifted out by the derrick, and lowered onto the wagon in less than a half-hour. The "wrecking" of the News Building means a loss of nearly $300,000—its cost for construction. The only salvage is the value of the concrete ballast and what the mill pays for the steel, which is classified as scrap. The work is an illustration of how modern enterprise does not hesitate to sacrifice property where its increase in business requires greater facilities for operation.



THE BOOM DERRICK USED FOR LOWERING THE MATERIALS TO THE WAGONS

COMPRESSED-AIR DRILL CUTTING THROUGH A GIRDER THREE FEET THICK

CUTTING THE STEEL RODS WITH THE OXYGEN BURNER.

LOWERING EIGHT TONS OF CONCRETE AND STEEL TO THE STREET

DEMOLISHING A REINFORCED CONCRETE BUILDING

The South Sea Swells

Every reader of books of travel will remember with what frequency in the old narratives of experiences in the South Seas reference is made to the heavy swells of the ocean, which impressed the navigators with the idea of their remoteness from land.

The great size of the sea waves in high southern latitudes has been explained by the fact that south of the Cape of Good Hope and Cape Horn there is neither windward nor leeward shore, and the prevailing wind in all longitudes is westerly. Thus when a west wind springs up it finds a long westerly swell, the effect of a previous wind, still running. The new-born wind increases the steepness of this swell, and so forms majestic storm waves, which sometimes attain a length of twelve hundred feet from crest to crest. The average height attained by sea waves in feet is about half the velocity of the wind in miles per hour.

Research as a Financial Asset*

The Money Value of Pure Science

By Willis R. Whitney

Director, Research Laboratory, General Electric Company, Schenectady, N. Y.

IT is only in our century that there could be much significance to such a title as "Research as a Financial Asset." This is an industrial century, and, whether we are proud of it or not, we are an industrial people. For some reasons it may be thought unfortunate that so large a proportion of man's energies should be devoted solely to the industries. In some eras we find that there was a predominance of art over industry; in others literature was predominant, in still others war and conquest. Once territorial discovery and acquisition predominated, and now, in our own times, the principles of community interest have so greatly developed that we are accustomed to seeing many people who, instead of directly producing their own necessities of life, are more generally repeatedly producing some one little article which contributes in the lives of others. This we recognize as a natural tendency to higher efficiency. Our intricate and delicately balanced system of work is becoming continually more complex, but is certainly still covered by the elemental laws of demand and of survival. New discoveries in our day are largely mental, instead of geographical, and the old battles of conquest have become wars with ignorance. They are struggles to overcome inefficiencies, attempts to broaden the common mental horizon, as our ancestors broadened their physical horizon. Very few people realize the rapidity with which technical advances are being made. Few realize how the way of this advance has itself advanced. I might make this more clear by an illustration.

Consider for a moment the increasing uses of chemical elements and compounds. New combinations in alloys, medicines, dyes, foods, etc., and new uses and new materials, are being produced daily. For a more simple comparison, consider only the advances in technical uses of the metallic elements.

Copper, iron and five other metals were known and used at the time of Christ. In the first 1800 or 1900 years of our era, there were added to the list of metals in technical use (pure or alloyed) about eight more, or a rate below three a century. There has been so much industrial advance made within the past twenty or thirty years that fourteen new metals have been brought into commercial use within this period. This is almost as many in our quarter century as in the total preceding age of the world. Of course this rate, as applied to metals, apparently cannot continue, but there is no reason to question the possibility of the general advance it indicates. For centuries a single metal was made to serve for all uses which that metal could fill. Then two metals divided the field, each being used where it was preferred for any reason. Alloys began to displace metals to a limited extent. While the engineer still uses iron for his railroad, iron for his buildings and iron for his tools, these irons are different and have been specially developed for those uses. The electrical engineer prefers copper for his conductor, certain irons for the frames of apparatus, other special irons and steels for the shafts, the magnetic fields, etc., and the specialization to best meet specific wants is still under way. I suppose that this kind of complex development is largely responsible for research laboratories.

A research laboratory is a place where men are especially occupied with new problems, presumably not too far in advance of technical application. By this group devoting its entire attention to the difficulties of realizing already well defined necessities, or of newly defining and realizing together, the efficiency of these processes is increased. Men specially trained for this very purpose are employed and they are usually just as unfitted for successfully manufacturing as those who efficiently reproduce are of discovering or inventing. It is merely an extension of the principle of the maximum efficiency. A man with his entire attention devoted for months or years at a time to the difficulties of a single problem should be better able to reach a solution than the man who can devote only irregular intervals to it. He should then also be the better prepared for a second problem.

A research laboratory is also a place equipped with apparatus especially designed for experimental work. In a busy manufacturing plant, if a foreman has an idea pointing toward an improvement of his product he frequently has great difficulty in finding the time, the necessary idle apparatus, the raw materials and the incentive to try it. In the laboratory all of these are combined and there is added a system of co-operation, of permanently recording results and an atmosphere of research.

The mathematics of co-operation of men and tools is interesting in this connection. Separated men trying their individual experiments contribute in proportion to their numbers, and their work may be called mathematically additive. The effect of a single piece of apparatus given to one man is also additive only, but when a group of men are co-operating, as distinct from merely operating, their work rises with some higher power of the number than the first power. It approaches the square for two men and the cube for three. Two men co-operating with two different and special pieces of apparatus, say a special furnace and a pyrometer, or an hydraulic press and new chemical substances, are more powerful than their arithmetical sum. These facts doubtless assist as assets of a research laboratory.

When a central organization such as a laboratory has access to all parts of a large manufacturing plant and is forced sooner or later to come into contact with the various processes and problems, the various possibilities and appliances, it can hardly fail to apply, in some degree, the above law of powers.

As a possible means of illustrating the almost certain assistance which one part of a manufacturing plant may give another when they are connected by experimenting departments or research laboratories, and how one thread of work starts another, I will briefly review part of a single fairly connected line of work in our laboratory. In 1901 the meter department wanted electrically conducting rods of a million ohms resistance. These were to be one-quarter inch diameter by one inch length. In connection with this work we had to become fairly familiar with published attempts at making any type of such high resistances. Some kind of porcelain body containing a very little conducting material seemed a fair starting formula after the resistance of almost all kinds of materials had been considered. Our own porcelain department was of great help in showing us how to get a good start. We learned how and what to mix to get a fair porcelain, and we found that small quantities of carborundum or of graphite would give us the desired resistance about once in a hundred trials. The rods could be made, but the variation of their resistance when taken from the porcelain kiln and when they were made as nearly alike as we could make them, was often so many thousand fold that something new had to be done to make a practical success. A small electric furnace was then devised for baking the rods, and this was so arranged that the rate of rise of temperature, the maximum temperature reached and the duration of heat at any temperature were under control and were also recorded. The desired result was obtained and this work was thus finished. It gave us a certain stock of knowledge and assurance.

At that time a very similar problem was bothering one of the engineering departments. Lightning arrester rods, part of the apparatus for protecting power lines from lightning, were needed. Their dimensions were $\frac{3}{4} \times 6$ inches, and they needed to have a definite, but, in this case, *low* resistance, and could apparently not be baked in a porcelain kiln. The necessary variations in such a kiln are so great that in practice many thousand rods were repeatedly fired and afterward tested to yield a few hundred of satisfactory product. All the cost of making an entire batch would have to be charged against the few units which might be found satisfactory, and in many cases there were none good in a thousand tested. It was evident that regulation and control of temperature was necessary. This was found to be impracticable in case any considerable number were to be fired at one time, as the heated mass was so great that the rods near the walls of the retort received a very different heat-treatment from those near the middle and were consequently electrically different. This was still the case even when electrically heated muffles were used. This difficulty led to experiments along the line of a heated pipe, through which the rods could be automatically passed. Some time was spent in trying to make a practical furnace out of a length of ordinary iron pipe, which was so arranged as to carry enough electric current to be heated to the proper baking temperature. Troubles here with oxidation of the iron finally led to substitution of carbon pipes. This resulted in a carbon tube furnace, which is merely a collection of 6-foot carbon pipes, embedded in coke powder to prevent combustion, and held at the ends in water-cooled copper clamps, which introduce the electric current. By control of this current the temperature could be kept constant at any point desired. When this was combined with a constant rate of mechanical feed of the air-dried rods of porcelain mixture, a good product was obtained. For the past seven years this furnace has turned out all the arrester rods, the number produced the last year being over 100,000 units.

In this work we were also forced to get into close touch with the electroplating department. The rods had to be copper plated at the ends, to insure good electrical contact. The simple plating was not enough. This introduced other problems, which I will pass over, as I wish to follow the line of continuous experiment brought about, in part, at least, by a single investigation. The electric furnace consisting of the carbon tube packed in coke was a good tool for other work, and among other things we heated the carbon filaments for incandescent lamps in it. We were actuated by a theory that the high temperature thus obtainable would benefit the filament by removal of ash ingredients, which we knew the ordinary firing methods left there. While these were removed, the results did not prove the correctness of the theory, but rather the usefulness of trying experiments. It was found by experiment that the graphite coat on the ordinary lamp filament was so completely changed as to permit of a hundred per cent increase in the lamp life or of a twenty per cent increase in the efficiency of the lamp for the same life, so that for the past four or five years a large part of the carbon lamps made in this country have been of this improved type. This is the metallized, or Gem lamp. Naturally, this work started a great deal of other work along the lines of incandescent lamp improvement. At no time has such work been stopped, but in addition to it, the new lines of metallic filament lamps were taken up. In fact, during the past five or six years a very large proportion of our entire work has been done along the line of metallic tungsten incandescent lamps. In this way we have been able to keep in the van of this line of manufacture. The carbon tube furnace has been elaborated for other purposes, so as to cover the action under high pressures and *in vacuo*. Particularly in the latter case a great deal of experimental work has been carried out, contributing to work such as that connected with rare metals. In such a furnace, materials which react with gases have been studied to advantage. Our experience with the metallized graphite led to production of a special carbon for contact surfaces in railway signal devices, where ordinary carbon was inferior, and suggested the possibility of our contributing to improvements in carbon motor generator brushes. On the basis of our previous experience and by using the usual factory methods, we became acquainted with the difficulties in producing carbon and graphite motor brushes with the reliability and regularity demanded by the motor art.

Furnace firing was a prime difficulty. Here again we resorted to special electrically heated muffles, where the temperatures, even below redness, could be carefully controlled and automatically recorded. This care, aided by much experimentation along the line of composition, of proportionality between the several kinds of carbon in the brush, etc., put us into shape to make really superior brushes. The company has now been manufacturing these for a couple of years, with especial reference to particularly severe requirements, such as railway motors. In such cases the question of selling price is so secondary that we can and do charge liberally for delicacy and care of operation in the manufacture.

This carbon work naturally led to other applications of the identical processes or materials. Circuit breakers, for example, are now equipped with a specially hard carbon contact, made somewhat as motor brushes are made.

It is not my intention to connect all of the laboratory work to the thread which seemed to connect these particular pieces of work, but rather to show the possible effect in accumulating in a laboratory experiences which should show on an inventory.

Among other considerations which appeal to me is one which may be worth pointing out. Probably almost every manufacturing plant develops among its workmen from time to time men who are particularly endowed with aptitude for research in their

*Presented before the Congress of Technology at the Fiftieth Anniversary of the Granting of the Charter of the Massachusetts Institute of Technology.

line. They are usually the inventors of the company. They are often discovered in spite of opposition. They are always trying new things. They are almost of necessity somewhat inefficient in the routine production. In many plants they are merely endured, in a few they are encouraged. In my mind their proper utilization is a safe investment. A research laboratory assists in such a scheme. Sooner or later such a laboratory becomes acquainted with this type of men in a plant and helps them in the development of their ideas.

It is not a perfectly simple matter to measure the value of a research laboratory at any one time. In the minds of some, the proper estimate is based on the money already earned through its work, which otherwise would not have been earned by the company. This is a fair and conservative method which in our generation ought to be satisfactory when applied not too early to the laboratories. It does not take into account what we may call the good will and inventory value, both of which should be more rapidly augmenting than any other part of a plant. The experience and knowledge accumulated in a general research laboratory is a positive quantity. In our own case we expended in the first year not far from $10,000, and had little more than expectations to show for it. Our expenses rapidly rose and our tangible assets began to accrue. Perhaps I can point to no better criterion of the value of a research laboratory to our company than the fact that its force was rapidly increased by a company which cannot be particularly interested in purely academic work. Our annual expenditures passed the $100,000 mark several years ago. My own estimate of the value would probably be greater than that of others, for I am firmly convinced that proper scientific research is demanded by the existing conditions of our technical age.

Without going into exact values, which are always difficult to determine, consider for a moment the changes which incandescent lighting has witnessed in the past ten years. In this field our laboratory has been active in contributing to both carbon and to metallic filaments. Moreover, all of the improvements in this field have been the product of research laboratories of trained men. In the case of our metallized carbon filament, which has now been in use several years, the efficiency of the light was increased by about twenty per cent. Among the carbon lamps of last year these were sold to the extent of over a million dollars.

A broader, but perhaps less accurate impression of changes recently produced, may be gained by considering the economy now possible on the basis of our present incandescent lamp purchases in this country and that which would have resulted if the lamps of only ten years ago were used in their stead. On the assumption that the present rate of lamp consumption is equivalent to about 80,000,000 25-watt tungsten lamps per year, and on the basis of one and a quarter watts per candle power as against 3.1 of the earlier lamps and charging power at 10 cents per kilowatt hour, we get as a result a saving of $240,000,000 per year, or two-thirds million per day. Naturally, this is a saving which is to be distributed among producers, consumers and others, but illustrates very well the possibilities. It is interesting to note that we are still very far removed from a perfect incandescent illuminant, when considered from the point of view of maximum theoretical light efficiency.

I see from advertisements that 65,000 of the magnetite arc lamps, originally a product of the laboratory, are now in use. These must have been sold for something near $2,000,000. The supplying of electrodes, which we make and which are consumed in these lamps, should amount to about $60,000 per year.

Our study of the properties of the mercury arc produced our rectifier, which has been commercially developed within the past few years. Of these, about 6,000 have been sold. As they sell for not far from $200 per set, it is safe to say that this also represents a sale of over a million dollars. The advantage of these outfits over other available apparatus must also be recognized as not far from $200 for each hour through which those already sold are all operating.

In such a complex field as insulations and molded materials there have been many changes produced. As far back as 1906 we were using annually, in a certain apparatus, 30,000 specially drilled and machined soapstone plates, which cost $1.10 each. As the result of experiments on substitutes for such material, it was found that they could be molded by us in the proper shape, with holes in place and of a material giving increased toughness, at a greatly reduced cost. As the result of this fact, the price of the purchased material was reduced to us from $1.10 to 60 cents, which in itself would have paid for the work. But further developments proved that the new molded material could be made for 30 cents, which the foreign material could not equal, so we have since produced it ourselves. This caused a saving of approximately $21,000 annually for this one molded piece. I have heard of other cases where prices to us have gone down, when we have obtained a little promise from our experimental researches.

In considering the research laboratory as a financial asset there is another view which might not be visible at first sight. It is the question of the difference between the value of the useful discovery when purchased from competitors in the business and when made by one's own company. It is not usually pleasant to have to purchase inventions after their value is known, no matter from whom, but to have to pay a competitor for such a discovery is doubly irksome. One is naturally unduly fearful of its value to the competitor, and he, in turn, is overestimating another's power to use it. The purchaser's profit is apparently limited to the differences between his efficiency of operating it and that of the original owner. A business usually comprises processes of making and selling something at a profit, and study of the making of the most modern, most improved, most efficient, is about as essential as the study of the limits of safe business credits.

I was recently informed by an officer of another large manufacturing company, where much chemical work is done and which established a research laboratory several years ago, that the most important value they got from their laboratory was the assurance that they were keeping ahead and are at least prepared for the new, if they cannot always invent it themselves. Incidentally, he said that from one part of their research work they had produced processes, etc., which had saved $800,000 a year. They are at present spending in their several research departments a total of about $300,000 a year.

We hear frequent reference to the German research laboratories and a brief discussion may be in place. For the past fifty years that country has been advancing industrially beyond other countries. Not by newly opened territories, new railroads, new farm lands, new water power sites, but by new technical discoveries. In fact, this advance may be said to be largely traceable to their *apparent* over-production of research men by well fitted universities and technical schools. Every year a few hundred new doctors of science and philosophy were thrown on the market. Most of them had been well trained to think and to experiment; to work hard, and to expect little. The chemical manufactories began to be filled with this product and it overflowed into every other calling in Germany. These well educated young men became the teachers, the assistants and the professors of all the schools of the country. They worked for $300 to $500 per year. They were satisfied so long as they could experiment and study the laws of nature, because of the interest in these laws instilled into them by splendid teachers. This condition soon began to make itself manifest in the new making of things—all sorts of chemical compounds, all kinds of physical and electrical devices. I might say that pure organic chemistry at this time was academically most interesting. Its laws were entrancing to the enthusiastic chemist and consequently very many more doctors were turned out who wrote organic theses than any other kind. What more natural than that organic chemistry should have been the first to feel the stimulus? Hundreds, and even thousands of new commercial organic products are to be credited to these men and to that time. All the modern dye stuffs are in this class. Did Germany alone possess the raw material for this line? No! England and America had as much of that. But Germany had the *prepared men* and made the start.

It seems to me that America had made a start in preparing men for the research work of its industries. For example, it is no longer necessary to go abroad to get the particular training in physical chemistry and electro-chemistry which a few years ago was considered desirable. Advanced teaching of science is little, if any, more advanced in Germany to-day than it is in this country. In my opinion the quality of our research laboratories will improve as the supply of home trained men increases, and that the laboratories of this kind will be increasingly valuable when analyzed as financial assets. I am certain, too, that the industries will not be slow in recognizing the growing value of such assets. They merely want to be shown.

Probably in most industries there are what I may call spots particularly vulnerable to research. For example, the efficiency of steam boilers, based upon the heat energy of the coal used and the efficiency of the engine using the steam, is continually being raised. We may expect, until the maximum calculable efficiency is reached, that this advance will continue. The reason is not far to seek. It is a vulnerable spot. Improvement is possible. A small increase in efficiency of a power plant is an ever-continuing profit. Great numbers of steam power plants exist, and so inventors are influenced by the fact that new improvements may result in enormous total economies. Every rule of the game encourages them. I can make this clearer by illustrations.

Artificial light is still produced at frightfully poor efficiency. Electric light from incandescent lamps has been greatly improved in this respect, but there is still room for greater economies. It is still a vulnerable spot.

In the case of iron used in transformers, we have another such vulnerable spot. A transformer is practically a mass of sheet iron, wound about with copper wire. The current must be carried around the iron a certain number of times and the copper is chosen because it does the work most economically. No more suitable material than copper seems immediately probable, nor is there any very promising way of increasing its efficiency, but in the iron about which it is wound there is a vulnerable spot. The size of the iron about which the copper is wound may possibly be still much further reducible by improvements in its quality. In other words, we do not yet know what determines the magnetic permeability or the hysteresis of the iron, and yet we do know that it has been greatly improved in the past few years and that it can still be greatly improved.

Let us make this vulnerable point a little clearer by considering the conditions here in Boston. I assume there are approximately 50,000 kilowatts of alternating current energy used here. Nearly all of this is subject to the losses of transformers. If the transformers used with this system were made more than ten years ago, they probably involve a total loss, due to eddy and hysteresis, of about $1,000 per day, at the ten-cent rate. Transformers as they are made to-day, by using improved iron, are saving nearly half of this loss, but there still remains over $500 loss per day, to serve as a subject for interesting research work.

It should also be noted that Boston uses only a very small fraction of the alternating current energy of this country.

Consider for a moment two references to the sciences and industries in Germany and England. Dr. O. N. Witt, professor in the Berlin Royal Technical High School, reporting to the German government in 1903, says: "What appears to me to be of far greater importance to the German chemical industry than its predominant appearance at the Columbian World's Fair, is the fact which finds expression in the German exhibits alone, that industry and science stand on the footing of mutual deepest appreciation, one ever influencing the other," etc. As against this, Prof. H. E. Armstrong, of entirely corresponding prominence and position in England, says of England: "Our policy is the precise reverse of that followed in Germany. Our manufacturers generally do not know what the word research means. They place their business under the control of practical men—who, as a rule, actually resent the introduction into the work of the scientifically trained assistants." If the English nation is to do even its fair share of the work of the world in the future, its attitude must be entirely changed. It must realize that steam and electricity have brought about a complete revolution, that the application of scientific principles and methods is becoming so universal elsewhere that all here who wish to succeed must adopt them.

So long as motors burn out, so long as subways are tied up by defective apparatus, so long as electric motors can run too hot, so long as street cars can catch fire from so-called explosions of the current, so long as the traffic of a whole city can be stopped by a defective insulation or a ten-cent motor brush, there will probably be the equivalent of research laboratories somewhere connected with the electrical industries, where attempts will be continually made to improve.

Electrical Effects Accompanying the Fermentative Activity of Yeast

PROF. M. C. POTTER, at the recent soirée of the Royal Society, exhibited an apparatus consisting of a glass jar containing a porous cylinder, and into each of these are introduced solutions of glucose of equal concentration. Two platinum electrodes are placed, one in the jar and one in the porous cylinder, and on the introduction of yeast into one of the solutions, the whole constitutes a type of galvanic cell. The leads from the electrodes are connected with a condenser, and the condenser is discharged through a galvanometer by means of a Morse key. By this method the E.M.F. developed through the action of the yeast may be registered and compared with that derived from a standard cell.

Perpetual Stamp Pads (Deiterich's)

THIRTY-FIVE parts of Japanese gelatine, Tjen-Tjan are boiled until dissolved with 3,000 parts of water, passed boiling hot through flannel, rinsed with 600 parts of glycerine and concentrated, by evaporation, to 1,000 parts. One hundred parts of this mixture mixed with 6 parts of methyl-violet 3B, or 8 parts of eosine BBN, or 8 parts of phendline blue 3F, or 5 parts of anivne green D or 10 parts of nigrosine, supplies the correspondingly colored stamp pad, which is poured into a shallow tin box and covered with thin muslin (mull). If the surface becomes too dry, it may be moistened with water or glycerine.

Diesel Marine Engines—III*

A Resume of Recent Performances

By Herr Th. Saeuberlich of Osterholz-Scharmbach

Concluded from Supplement No. 1847, page 334

The introduction of the crude oil motor, especially the Diesel motor, may be regarded as of epoch-making significance in the fishing industry. In other countries, notably in Holland and Denmark, there are already many small vessels working with motors, but Germany has only a small number to show. Generally speaking, the fishing trade in Germany in recent years can only be described as bad, and in face of this fact the introduction of the Diesel motor to-day must appear especially full of promise, for it opens a new perspective to the herring fishery, and it is to be hoped will have great influence in bringing about the fulfillment of the dream that Germany's requirements in the way of herrings may be met by Germany's own fisheries. At present only a fraction of her needs is covered by her own production.

The motor lugger Ewersand, now to be described, returned at the end of October from a five weeks' fishing cruise on which she had been sent for trial purposes by the Frerichs Company in conjunction with the Braker Herring Fishery, and not more than three tons of crude oil was used, while steam luggers on the same work used twenty tons of coal. The fuel consumption of three tons of oil can be still further reduced, since on this cruise especially bad weather prevailed, and by carelessness of the crew a portion of the oil was lost.

It was thought advisable to provide for a small auxiliary plant exactly similar to that usually employed on sailing luggers for hauling in the nets. It would have been an easy matter to haul in by the motor, but it was not considered advisable at first to have the safety of the net entirely dependent on the motor. The motor has proved itself reliable in the worst weather, and on the last return voyage from the fishing ground ran for about seventy-five hours in a high sea without interruption.

The fuel is stored in a fixed tank in the engine room, and takes comparatively little room in a position forward, which has not been occupied previously.

A further advantage gained from the employment of crude oil is that the cleansing of the herring casks in which, generally speaking, a part of the coal is stored, is obviated.

Trials have shown that in every respect crude oil can be relied upon for work at sea, and that, in consequence of the small space required and the low fuel consumption, there can be no doubt that it will replace steam engines for herring fishing boats.

In the construction of the motor equipment of the herring lugger, now to be described, it has again been kept in mind that everything should be as simple as possible. Above all, it was of importance, because in uncustomary work this constitutes the chief difficulty, that in bad weather extensive overhauling and repair should be rendered wholly unnecessary.

The construction of the lugger motor is, for the most part, the same as that of the service boat engine already described. A high-speed two-cylinder motor developing 80 to 90 effective horse-power with 330 revolutions is used, reversing being effected by a friction coupling and gearing. From the constructional point of view, special attention may be directed to the pedestals, and the separate cylinders—see Figs. 20 to 22. The peculiarity of the construction consists in the fact that the front column can be removed without taking the engine apart, and therefore it is possible, if required, to take out the crank shaft from the front without much trouble. Having regard to the limited space in craft of this sort, it becomes an absolute necessity that every part should be readily accessible.

With the reversing drive—Fig. 23—it is possible to carry out three different evolutions, the fly-wheel revolving constantly in one direction.

(1) Friction coupling and brake blocks disengaged. The propeller shaft remains stationary. The small pair of wheels driven by the wheel keyed to the crank shaft on the large wheel on the propeller shaft, the casing and the friction coupling revolving in the same direction as the fly-wheel, but at half its speed. In this state the engine runs light.

(2) Ahead gear; friction coupling, and brake engaged. The fly-wheel, brake ring, and coupling form a rigid system with the wheel casing. The direction of rotation and number of revolutions of the propeller shaft are the same as that of the crank shaft.

(3) Astern gear coupling thrown out of gear, brake blocks thrown into gear. In this case the wheel casing is held fast and with it the arm *E*. The wheels again revolve separately and the propeller shaft now revolves in a contrary direction to the crank shaft.

Reversing gears and reversing screws make exceedingly simple engine construction possible, especially the employment of a small number of cylinders, and on this account are to be specially recommended for the rough work of the fishing industry.

Comparisons.—It may now be not uninteresting to draw a few comparisons between motor and steam ships, but it stands to reason that in so doing only the most important points can be noticed, and it would not be fair to generalize from these comparisons. Such comparisons are influenced to a high degree by the size, and especially by the kind of vessel and the purpose for which she is employed. Moreover, the efficiency of the screw has to be left out of account. It is therefore only possible to show on broad lines the advantages of the Diesel engine for marine propulsion.

If the service boat above described had been fitted up for steam, an engine of only 100 indicated horse-power could have been employed, and it would have given the vessel a speed lower by about 1½ knots, and a towing power of no more than 1,320 kilos. Besides, only a short cabin could have been accommodated. In Table II. are given the relative dimensions of three vessels for comparison.

I.—Motor service boat.

Ia.—Steam service boat of same dimensions and displacement as the motor service boat.

Fig. 20.—90 HORSE-POWER TWO-CYLINDER ENGINE OF THE EWERSAND—FRONT

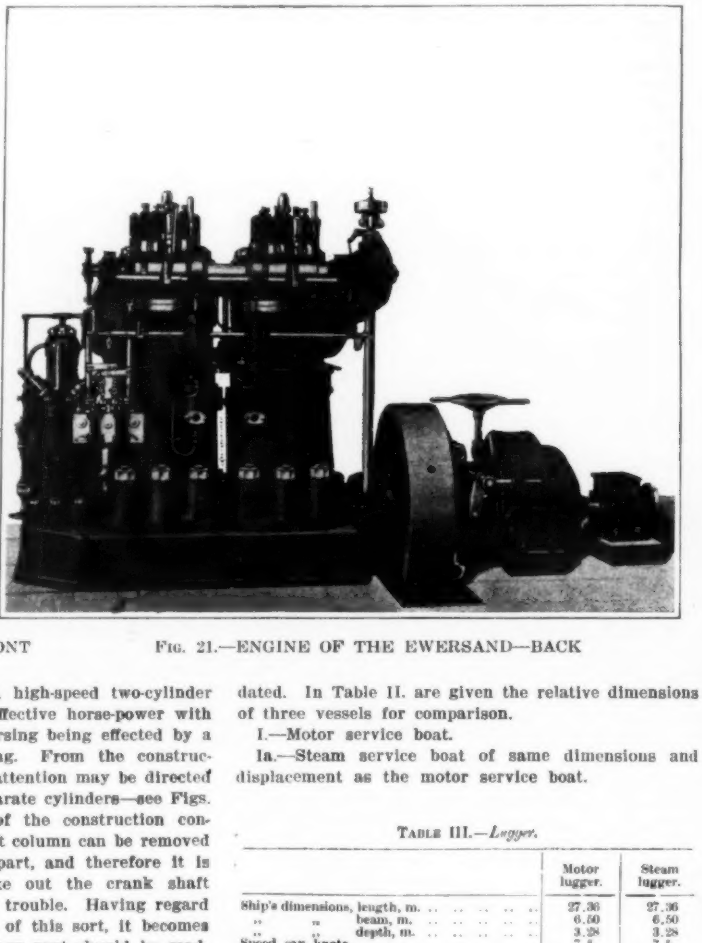


Fig. 21.—ENGINE OF THE EWERSAND—BACK

Table II.—*Service Boat.*

	I.	Ia.	II.
Vessel's dimensions, length, m.	18.00	18.00	21.50
" beam, m.	4.90	4.90	4.90
" depth, m.	2.50	2.50	2.60
" draught, m.	1.90	1.90	2.00
Weight of ship equipped fully with oil or coal for 240 sea miles radius of action, tons	72.3	72.3	105.0
Normal power of engine or motor, H.P.	160	80	160
Pull on the tow-rope at 5 knots speed, kilos.	2200	880	2200
Radius of action in sea miles	240	240	240
Speed without towing, about, knots	9.5	8.0	9.5
Time for 240 sea miles at above speed without towing, hours	25¼	30	25¼
Oil or coal consumption for 240 sea miles, say	1000	3300	5100
Oil or coal consumption for 240 sea miles, say, m.	75	58	92
Cost	£3000	£2500	£3250
Steam Boat—			
Smaller towing power than motor vessel	60%	—	—
Lower speed than motor vessel, say	16%	—	—
Loss of time in proportion to the motor vessel	19%	—	—
Greater cost than motor vessel	—	—	£250
Greater working cost per 1000 sea miles than motor vessel	—	—	£3 10s.

Table III.—*Lugger.*

	Motor lugger.	Steam lugger.
Ship's dimensions, length, m.	27.36	27.36
" " beam, m.	6.50	6.50
" " depth, m.	3.28	3.28
Speed, say, knots	7.5	7.5
Displacement, cubic metres	254	254
Lugger on the home voyage with full equipment, but without cargo, tons	140	164
Number of casks below deck	760	600
" fish compartments	12	9½
Cargo, weight, tons	114	90
Number of nets	100	130
Average fuel consumption per voyage in kilos, say	3000	20,000
Average fuel consumption per voyage	£7 4s.	£18
Cost without fishing equipment, say	£3500	£3500
Motor lugger, more casks	160 = 21%	—
" " nets	30 = 18¾%	—
" average lower working cost per voyage, say	£13	—
Crew	Same in both cases	

Table IV.—*Fishing Boats.*

	Motor vessel.	Steam vessel.	Steam vessel.
Length, m.	35.5	35.5	39.3
Beam, m.	6.7	6.7	7.0
Depth, m.	3.75	3.75	4.35
Motor or engines, indicated horse-power	400	300	450
Speed, about, knots	11	10	11
Maximum displacement, cubic metres	400	400	550
Radius of action	the same for all 3 ships		
Fuel for one voyage, about 21 days, kilos.	32,000	100,000	150,000
Fuel, cost	£76 15s.	£90	£135
Fish and ice capacity, cubic metres	165	115*	165*
Fish and ice tonnage	135	94	135
Crew, men	12	10	14
Cost	£8000	£7000	£9650

* Including reserve bunker.

* Abstract translation by *The Engineer* (London) from a paper read before the Shiffbautechnischen Gesellschaft and published in the *Journal* of the Society by Julius Springer, Berlin.

II.—Steam service boat of the same towing power as the motor service boat.

The comparison between a steam trawler and a motor propelled trawler is even more favorable to the latter.

A motor lugger of exactly the same body plan and of the same dimensions as a steam lugger is, in consequence of the smaller space occupied by the engine and its lighter weight, in a position to take at least 160 more casks of herrings below decks than the steam lugger, and can also carry at least 30 more nets. Taking the value of the herrings at 30s. per ton, the Diesel boat is able to earn about £1,125 more per year.

To this must be added a very notable economy in fuel.

For the purpose of comparison, particulars of three vessels are given in Table IV. The first is a motor fishing vessel of the small type, the second a steam vessel of the same dimensions, and the third a steam boat of larger size.

In conclusion, two cargo ships of about 5,400 tons burden—one driven by oil, the other by steam—are taken for comparison, the former being under the disadvantage that it carries its own fuel for the return voyage, while the latter does not.

The concluding pages of Herr Saeuberlich's paper are occupied with a discussion of the sources of Diesel oil throughout the world, its cost, and the ports at which supplies are purchasable. Its price free on board at Hamburg is given as between M. 45 and 50.

TABLE V.—*Cargo Vessels.*

Type of ship.	Motor.	Steam.
Dimensions, length, m.	103	103
„ beam, m.	14.6	14.6
„ depth, m.	9.6	9.6
„ draught, m.	6.55	6.55
„ coefficient of displacement	0.78	0.78
Effective H.P., taking mechanical efficiency at 90 per cent.	1350	1500
Gross tonnage	5550	5400
Fuel (double voyage for motor ship, single voyage for steam ship), tons	380	480
Carrying capacity, tons	5200	4920
Advantage in favour of motor vessel	280 tons	
Speed, knots	10	10
Fuel consumption (0.220 kilo./E.H.P.; 0.550 kilo./I.H.P.) daily, tons	7.13	19.8
	£ s. d.	£ s. d.
Fuel cost (£1 14s. for oil; 15s. 8½d. for coal) daily	12 2 0	15 11 0
Advantage of the motor ship, daily	3 9 0	
Crew: 1 First engineer, £15 per month	15 0 0	15 0 0
1 Second „ £9 „	9 0 0	9 0 0
1 Third „ £5 „	5 0 0	5 0 0
1 Eng. Assist., £3 „	—	3 0 0
1 Fitter, £5 „	5 0 0	—
6 Stokers and trimmers	—	22 10 0
2 Greasers at £3 15s.	7 10 0	—
Keep, 1s. 2½d. per man daily	10 16 0	18 0 0
Total wages and keep	52 6 0	72 10 0
Advantage of the motor vessel per month	20 4 0	

Saving yearly, *i.e.*, for four single voyages at forty steaming days—

	£ s. d.
(1) More earned in freight, 16s. per ton for full voyage, to and fro	896 0 0
(2) Fuel, 160 × £3 9s.	552 0 0
(3) Wages of crew, 404 × 12s.	242 8 0
	1690 8 0
(4) Interest on greater cost of motor equipment	125 0 0
Yearly saving	1565 8 0

(This may, perhaps, be somewhat reduced in consequence of the probable increase in lubricating oil required and of the higher cost of upkeep.)

Experiments with the Blind

IT is a well-known fact that blind persons can perceive obstacles near them when walking, either in front of them or at the side, or when standing still they perceive the approach of objects, even when these objects approach very slowly and without noise. This perception remains even when the person and the object are both quite at rest. Some claim that blind persons have a sixth sense, called sense of obstacles or by various other names. Many opinions have been given by scientists as to the cause of the sensation, and it is claimed that it is due to air pressure, heat, an unknown emanation or else to hearing. M. Truschel inclines to the last claim, after making experiments at the Blind Institution of Paris, in the presence of Dr. Marage, a prominent authority, and other persons. First, the blind man is seated and the author holds out a large sheet of carboard hung from a cane, bringing it near the person very slowly, sometimes in front and at others from the top downward, or making other movements. Five blind persons, one of them a professor, were chosen. First, the subject has the head bare. He perceives the object well on the two sides, less so in front and never behind him. Second, he stops the ears as well as the nose with the fingers. Here he never perceives the object before it touches him. Third, using 1½-inch rubber tubes put in the ears, the effect is much less. Fourth, when his head is enveloped in stiff paper the distance at which he notices the effect is lessened. When a wool hood is used, the effect becomes better, and the same is found for cloth of different thicknesses and colors. However, surrounding the head by a cardboard cylinder cuts off the effect entirely, as the cardboard replaces the distant object and he perceives it alone. When the floor is covered by carpet or the ground snow covered there is scarcely any effect given, and when there is no noise in the room the person no longer feels the approaching object. On the contrary, he feels it strongly when there are vehicles or tramways passing in the neighborhood, or else there is the noise of a fountain, a brisk fire or the like. It thus appears that sound plays the most prominent part in this supposed sixth sense. It is recognized that blind persons can sometimes make use of other sensations such as air movement, heat, odors, etc., but these are always felt as such.

Cement for Stone Goods.—Equal parts of cuttle bone and umber, burned and reduced to powder, are mixed with slaked lime and brick dust, rubbed down with varnish, and while still rubbing, 0.5 part of red lead added.

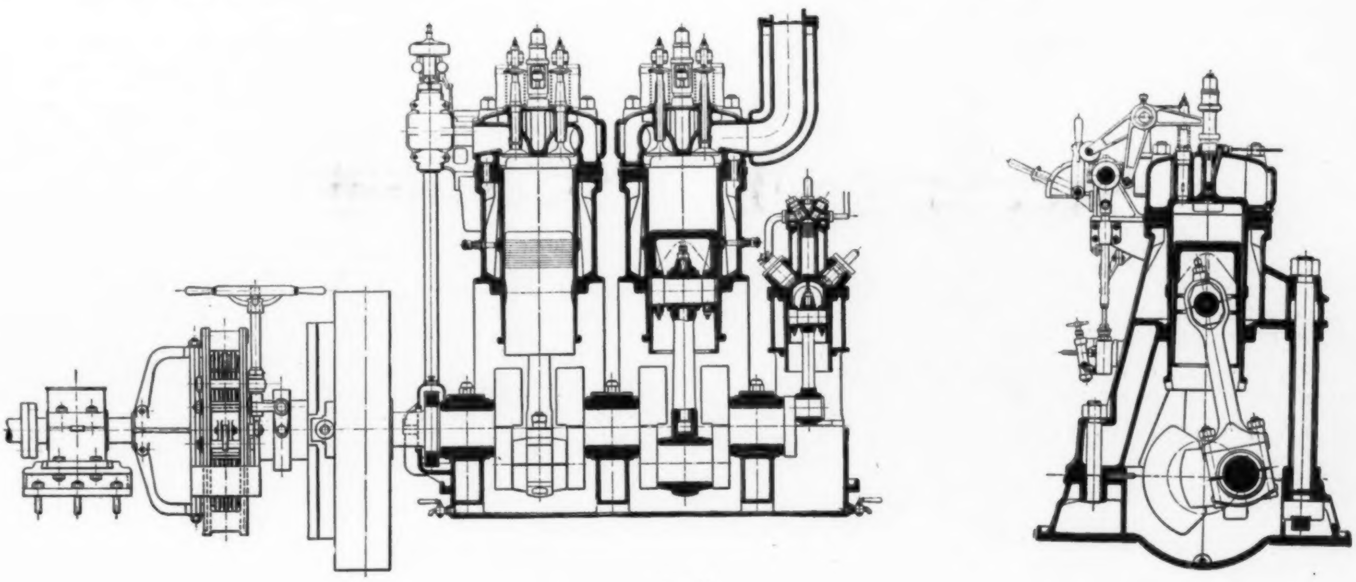


Fig. 22

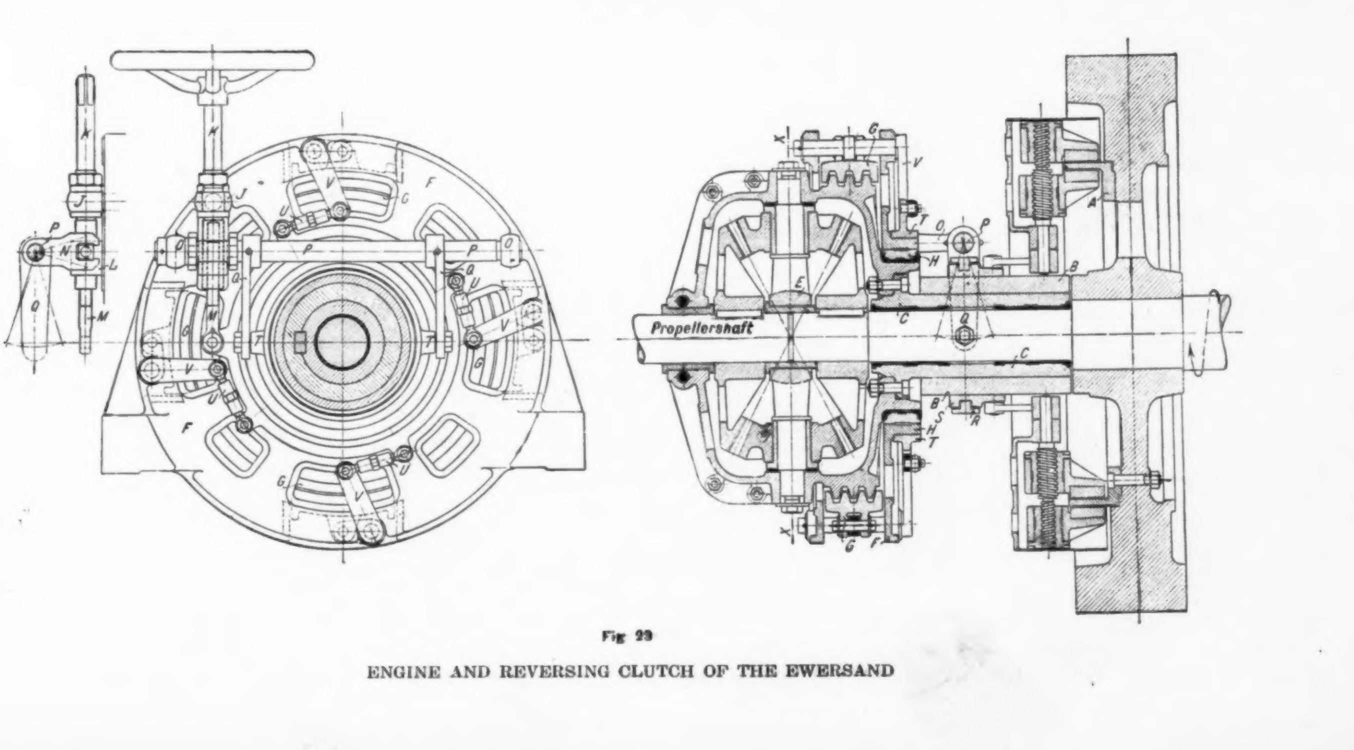


Fig. 23

ENGINE AND REVERSING CLUTCH OF THE EWERSAND

Recent Advances and Problems in Chemistry

Inaugural Lecture Before the Kaiser Wilhelm Society

By Prof. Emil Fischer

This lecture was delivered by Prof. Emil Fischer, of the University of Berlin, on the occasion of the inauguration of the Kaiser Wilhelm Society for the Advancement of Science on January 11th, in the Ministry of Education at Berlin, and is here reprinted from *Nature*.

Prof. Fischer traces the relations between science and scientific industries in Germany, pointing out that by affording facilities for the prosecution of pure scientific research, technical industry can only gain.

"At the present time, more than at any other period, we are inclined critically to examine the fundamental principles of all branches of knowledge, and, when necessary, to introduce far-reaching alterations in our original conclusions. This state of mind applies also to the natural sciences. During the last decades our actual knowledge has been extended to an extraordinary degree owing to new methods of research, and in view of the more recent observations the older theories have proved in many cases to be far too narrow. Even the fundamental principles of our knowledge appears, to a certain extent, to demand revision.

"Thus the progress in physical science forces us to adopt views which are incompatible with the older principles of mechanics, in spite of the fact that these were regarded as unassailable by thinkers such as Hermann von Helmholtz, Heinrich Hertz, and Lord Kelvin.

"We stand in the same position with respect to the elements in chemistry. Owing to the discovery of radium and similar bodies, we have been forced to the conclusion that chemical elements are not unalterable, and hence that their atoms are not indivisible.

"The same state of affairs obtains to even a greater degree in the biological sciences. In comparative anatomy, animal and vegetable physiology, theory of evolution, microbiology, and almost all branches of medical science, the rapid advance of experimental knowledge is accompanied by an equally rapid change in established theories. Even the semi-historical sciences, such as geology, palæontology, anthropology, and the venerable science of astronomy, are taking active part in the general progress.

"Thus in these times of general scientific activity is founded the Kaiser Wilhelm Society for the Advancement of Science, the primary object of which is the erection and maintenance of institutions of research.

"It need scarcely be said that we scientific investigators welcome this new and highly specialized creation with intense satisfaction, and I regard it as a particular honor to be permitted to be the first to give expression of our profound gratitude.

"No one will be able to assert that experimental research in Germany has been neglected; exactly the opposite conclusions must be drawn on contemplating the history of science during the nineteenth century. This displays a long series of brilliant scientific discoveries made in this country. The industries closely connected with science, such as the chemical and electrotechnical industries, fine mechanical engineering, production of metals, industries connected with fermentation, and last, but not least, agriculture, have also undergone in our hands a development envied on almost all sides by other nations.

"Should a criterion of the results of experimental research be desired, this may perhaps be found in the distribution of the Nobel prizes, which are awarded by absolutely independent corporations in Sweden.

"Only a month ago the Nobel prize for chemistry came for the sixth time to Germany; this constitutes 60 per cent of all the Nobel prizes hitherto awarded for chemistry. During the same period of time two and a half prizes were awarded to Germans for physics and three and a half for medicine. Dr. Alfred Nobel, unfortunately, did not provide for the remaining natural sciences.

"The majority of the investigations distinguished by the award of these prizes, however, belong to the nineteenth century. Since that time matters are to some extent altered. It is well known that the greater number of German scientific investigators are teachers at universities or polytechnics. During the last ten years a scheme of practical education of the masses has developed, which affords to all students the possibility of acquiring a thorough training in experimental science, and which provides our industries with an army of scientifically educated workers. But this very education of the masses tends mentally to exhaust the teacher to a great extent, certainly to a higher degree than is desirable, or indeed compatible, with the creative power of the investigator.

"There prevails in modern educational laboratories a condition of overstrained activity comparable with that existing in all but the smallest factories and commercial offices, and in the harassing cares of the day the teacher loses far too readily that peace of mind and broad view of scientific matters necessary for attacking the larger problems of research. This danger has been most keenly appreciated by teachers of chemistry, to which body I myself belong. It is therefore no mere accident that in our circles of recent years the cry for new laboratories should be at its loudest; an appeal for laboratories which should permit of research in absolute tranquillity unencumbered by the duties of teaching.

"In place of the one State-supported chemical institute which we had planned, chemists may now anticipate the immediate possession of two such institutes in which gifted men may conduct their original researches with ample means in freedom from any other duties. It is anticipated that the younger generation of chemists will thereby derive special benefit. By the younger generation I mean in particular those men who are at present acting as assistants or lecturers in university laboratories, and who can carry on research in addition to the servile labor of teaching only by possession of an extraordinary capacity for work.

"That which applies to chemistry may, *mutatis mutandis*, be applied to the other sciences, and is especially applicable to new branches of knowledge, for the prosecution of which the laborious organization of educational laboratories leaves no possibility.

"The handicap under which we work, in comparison with other nations, in particular the United States of America, in which similar institutes have recently been founded, can thus be removed. If the hopes which we all place in the new institutes are fulfilled, Germany will in the future not lack recipients of Nobel prizes, and we may then hope to maintain the honorable position which we hitherto have held in the domain of science.

That this is, however, not only a matter of sentiment and honor, but a palpable advantage in material respects, is at once evident from the close relation between modern scientific progress and national well-being. I am not here to demonstrate this relation by means of statistics or political economical considerations. On the contrary, I would invite your attention to a cursory review of my own science. I shall thus, in considering the most recent achievements in this field, be able to point out to you the diversity of the problems and their fertility with regard to the most varying branches of technical industry.

"As I have already remarked, our conception of the nature of chemical elements has to some extent altered owing to the discovery of radium, the first element to be discovered by a woman. We are now acquainted with more than twenty-four such substances—the so-called radio-active elements—and we recognize that they disintegrate spontaneously, and that elementary transmutations are hence possible.

"Germany took at the outset only a small part in the notable researches connected with the discovery of these elements, although the first stimulus leading to the discovery of radio-activity was given by the Röntgen rays. The reason for this is that Germany possesses none of the raw materials necessary for the production of radium, and that the majority of German investigators have not the means for the purchase of this costly element. This lack of means was especially keenly felt when radium first found profitable application in the fields of medicine.

"We are therefore all the more delighted to record such an event as the recent discovery due to Prof. Otto Hahn of the chemical laboratory of the University of Berlin.[1] He has for several years been investigating the disintegration products of thorium, which is employed in large quantities in the manufacture of incandescent mantles, and has in the course of his work discovered several radio-active elements, the most important of which he has designated mesothorium. He has, moreover, succeeded in devising a process for the isolation of this substance from the valueless waste products occurring in the manufacture of thorium. Hahn's preparation is the bromide of mesothorium, a white salt, which evolves the same highly penetrating rays as the corresponding salt of radium. For a given radio-active power this preparation costs only one-third as much as the radium salt. Nevertheless, it is not cheap, since for this small quantity of material $2,750 was paid. Thanks to an endowment from Dr. von Böttinger, of Elberfeld, the Akademie der Wissenschaften in this city will in a few months be in possession of 250 milligrammes of this substance, and lend it out to German investigators. It would be possible yearly to produce in Germany a quantity of this preparation of Dr. Hahn's equivalent to more than 10 grammes of pure radium bromide from the valueless residues after the extraction of the thorium. This is approximately equivalent to the world's stock of radium. By this discovery, the radium famine hitherto prevalent in Germany may be said to be relieved.

"The field of chemical experimentation has in the last decade been widened to an extraordinary degree by the ease with which it is possible to obtain very high and very low temperatures. High temperatures can now be obtained by means of electric furnaces with which temperatures up to 3,000 degrees are easily produced. Low temperatures may be obtained by means of liquid air. This commodity can now be purchased in Berlin at the comparatively low price of 43 cents per liter. For this we are indebted to his Majesty the Kaiser, who invited Prof. von Linde, of Munich, to erect here one of his large machines for the liquefaction of air.[2] You will understand how indispensable this liquid has become when I tell you that in the laboratories of the University of Berlin several liters are daily consumed for scientific purposes.

"Far more effective is liquid hydrogen, which affords a temperature lying 60 deg. C. below that of liquid air. The boiling point is as low as —252.6 deg. C., only 20.4 degrees above the absolute zero." The lecturer here explained that liquid hydrogen could not at the present time be obtained in Berlin, but that he was nevertheless able to show it to his audience, as he had received a shipment of the liquid, prepared that morning, from the University of Leipsic. He went on to show how the extreme lowness of the temperature of the liquid can be demonstrated by transferring a small quantity from its container into a transparent glass vessel, and immersing in it a glass tube sealed at the bottom. On removing the tube, it is seen to be filled with a white solid resembling snow; this is solid air; when once removed from the cooling liquid, the solid melts after a few moments.

Referring to the main stock of the liquid from which he had drawn his sample for the experiment, Prof. Fischer went on:

"The remainder of the liquid hydrogen in the containing vessel is to serve to-day for scientific purposes. At the end of my lecture it will find its way to the physico-chemical laboratory of the university, there to be employed this evening and during the night by Prof. Nernst for his important researches on the specific heat of the elements at temperatures in the vicinity of the absolute zero.

"When the Kaiser Wilhelm Institutes for Chemistry are once in full swing, we shall, I hope, no longer be obliged to travel to Leipzig every time we want some liquid hydrogen.

"Liquid hydrogen was prepared for the first time about twelve years ago by Prof. Dewar in the famous laboratory at the Royal Institution in London. But the costly experiments necessary for its production were rendered possible only by the liberal means which Dr. Ludwig Mond, the great benefactor of chemistry, placed at his disposal. Dr. Mond, moreover, has not forgotten his German Fatherland and German science. He bequeathed to the University of Heidelberg, where he had studied, the sum of $250,000 for chemical and physical research, and several years ago he endowed the State-supported chemical institute which he had planned, with the sum of $50,000.

"Inorganic chemistry, in which, thirty years ago, advance was scarcely considered possible, has, owing to the new aids to research—as, for example, high temperatures and powerful electric currents, etc.—undergone absolutely unexpected developments. I will merely give you some idea of this development by indicating a few processes of technical importance, beginning with the attempts to prepare valuable nitrogenous compounds from the nitrogen of the atmosphere.

"The direct production of nitric acid from air[3] by means of a powerful electric discharge has reached

[1] Dr. Hahn made the discovery of the mesothorium in the laboratory of University College, London, while investigating some thorianite residues given to him by Sir William Ramsay.

[2] A similar apparatus was independently devised and simultaneously patented by Dr. William Hampson in London.

[3] First carried out on a moderately large scale by Lord Raleigh (Trans. Chem. Soc., lxxi, 181).

the stage of large-scale manufacture. In Norway at the present moment a gigantic works, by the side of a mighty water-fall, is in course of erection by German factories in conjunction with Norwegian engineers, and supported by German and French capital.

"Synthetical saltpeter is already on the market, and German dye factories derive a considerable portion of the nitrites necessary for their work from the same source.

"The strikingly original process devised by Prof. A. Frank and Dr. N. Caro in Charlottenburg for the preparation of calcium cyanamide from calcium carbide and atmospheric nitrogen, came somewhat earlier into practice.

"And now a third process, based upon the direct combination of atmospheric nitrogen with hydrogen to form ammonia, has been announced. Prof. Haber, of Karlsruhe, by means of an ingenious application of the laws of physical chemistry, has succeeded in obviating the difficulties which hitherto have rendered this synthesis impracticable. The well-known Badische Anilin-und Sodafabrik at Ludwigshafen-am-Rhein has taken over his patents and technically perfected the process to such a degree that synthetical ammonia will in all probability shortly be placed on the market.

"The greater the number of such processes and the keener the competition which they excite, the greater is the benefit to the consumer. In the case I have just mentioned, this has an especial significance, as the bulk of technical nitrogenous substances are employed in agriculture for artificial manures.

"In the opinion of high authorities, German agriculture could easily consume twice, nay thrice, the amount of nitrogenous material at present employed for this purpose, were only the price to fall to a corresponding degree. In such a case it is possible that the crops would increase to such an extent that Germany could be independent of foreign countries with respect to agricultural produce. A task of great national importance has thus been set to chemical industry.

"This last process, the synthesis of ammonia, possesses the advantage that no electricity, merely heat, is involved. In other words, all that is necessary is fuel, a commodity of which Germany has ample store. Furthermore, it is to be noted that the cost of production depends only on the price of hydrogen, which, together with the inexpensive atmospheric nitrogen, serves as raw material. The problem of producing hydrogen at a moderate cost has already been solved by chemical industry, owing to the great interest recently taken in airships. In this way, the truth of the old saying is established—that all industries affect one another, and that improvements in one field may occasion fertile results in totally remote spheres of activity.

"Such a relation of mutual stimulus obtains also between theoretical chemistry and the production of metals. The production of gold, silver, and copper has gained in simplicity to an extraordinary degree by the introduction of electrochemical methods. The study, moreover, of alloys, and the perfecting of inexpensive methods of preparing metals hitherto obtainable only with difficulty, such as chromium, tungsten, manganese, vanadium, and tantalum, has been of immense benefit to the steel and electrotechnical industries."

As an example of the latest production of these industries, the lecturer at this point exhibited to his audience some samples of a new modification of iron, so-called "electrolytic iron." This material is prepared at the Langbein-Pfannhauser factory in Leipsic by a process devised by Prof. Franz Fischer in the laboratories of the University of Berlin, the iron being deposited from a solution of an iron salt by an electric current. The material can be readily rolled or drawn into wire. The samples had the form of extremely tough plates, reaching a thickness of five millimeters, and showed a bright surface, which is not due to any polishing, the metal being detached in that state from the electrode. Among the samples exhibited was a seamless iron tube, coiled in serpentine fashion, which had been deposited upon a leaden core.

This electrolytic iron is distinguished from all other commercial varieties by its extraordinary purity, in consequence of which it possesses distinctive physical properties. In particular, it is much more readily magnetized, and loses its magnetism far more rapidly than other kinds of iron, this property rendering it especially suitable for electromagnets. To illustrate this point, the lecturer here exhibited an electromotor of ordinary design, which had originally developed one-half horse-power, but which, on replacing the original electromagnets by others constructed of electrolytic iron, had its performance raised to 1¼ horse-power. This iron should prove of the greatest importance in the construction of electromotors.

Referring to the much discussed question of the husbanding of our natural resources, Prof. Fischer went on:

"Our present-day material civilization is to a great extent founded on the rapid utilization of the fossilized combustibles anthracite and brown coal. But posterity will not fail to reproach us with having grievously squandered this valuable material, for in the conversion of the heat of combustion of coal into energy in the ordinary way by means of steam engines, more than 85 per cent of the work potentially contained in the coal is lost. This loss, however, may be appreciably lessened by suitable chemical treatment of the coal. If the coal be first converted into combustible gas—so-called power gas—and this then consumed in a gas engine, the output of useful power is treble that developed in a steam engine. Valuable by-products—ammonia and tar—can, moreover, be recovered, and, indeed, the methods hitherto employed for the production of power gas are in many respects capable of improvement. I therefore deem it possible that at some time special institutes will be founded in the centers of the coal districts—perhaps under the auspices of the Kaiser Wilhelm Society—where these important problems can be investigated with the aid of all the methods known to science.

"Fossilized combustibles, which owe their origin to the vegetable kingdom, form a connecting link between mineral and organic substances. Organic chemistry surpasses inorganic chemistry in variety of methods and products to the highest degree. Small wonder, for it embraces all those complicated chemical bodies which occur in animal and vegetable life. The number of organic substances accurately investigated may to-day be estimated at the high figure of 150,000, and every year eight or nine thousand more are added to the list. We may therefore reckon that at the close of this century organic chemistry will comprise the entire gamut of substances found in the animal and vegetable kingdoms.

"This rapid increase is wholly due to organic synthesis. From the few elements occurring in organic chemistry, of which carbon predominates, all these compounds are built up, much as an architect produces the most diverse edifices from the same form of brick.

"Synthesis in organic chemistry is an offspring of Berlin. It was born eighty-two years ago in the Niederwallstrasse by the synthetical production of urea by Friedrich Wöhler. It has, moreover, found its greatest field of activity in Germany. It stands no longer in fear and trembling of the complicated constituents of the living organism. I shall demonstrate this fact by discussing the three classes of substance predominating in organic life: the fats, the carbohydrates, and the proteins. The synthesis of fats was effected so far back as two generations ago by Mr. Berthelot in Paris. The first synthetical carbohydrates—grape sugar, fruit sugar, etc.—saw the light twenty years ago in Würzburg; and the methods for the synthetical building up of albuminous substances have been worked out during the last ten years in the laboratory of the university of this city.

"Through such things as these proteins, carbohydrates, and fats, organic chemistry is brought into close touch with the biological sciences; for the entire metabolism in the living organism is merely a sequence of chemical transformations which these substances undergo. Chemistry is thus called upon to partake in the solution of the great riddles of life: Nourishment, growth, reproduction, heredity, age, and the manifold pathological disturbances of the normal state. It is not surprising that the keenest activity exists in these interesting fields of work, and we may safely hope that provision will be made for biological research in the new Kaiser Wilhelm institutes.

"The example given by the magnificent institute here in Berlin for the study of the problems of the industries connected with fermentation, in which the results of scientific research meet the practical requirements of brewers and distillers, serves to show how fruitful can be the collaboration of biologists and chemists.

"Moreover, chemical and many other industries have derived great benefit from organic chemistry. A few examples from recent times will illustrate this fact.

"The most widely distributed of all the carbohydrates is cellulose, of which cotton and linen are entirely composed, and which is the chief constituent of wood and plant fibers. And what a variety of articles is nowadays manufactured from cellulose! Paper, collodion, celluloid, photographic films, smokeless powder, artificial silk, artificial hair, artificial leather."

In illustration of the cellulose industries, the lecturer displayed before the audience samples of artificial silk and horse hair and films in great variety. All these products, he said, had been prepared by ingenious combinations of chemical and mechanical processes. Artificial silk and hair, in spite of their striking similarity to the natural products, Prof. Fischer explained, were of totally different composition from these, which are not derived from cellulose, but belong to the class of proteins. The lecturer further pointed out that the magnificent colors with which the artificial textures were dyed were the work of organic chemistry. "They belong," he said, "to the family of synthetic coal tar dyes. This subject is today so large that complete half-yearly courses of lectures are delivered upon it at the universities. Hundreds of such dyes are on the market, and the value of the dye stuffs produced in Germany, the majority of which are exported, approximates to fifteen millions of pounds sterling.

"Of all these dyes I shall only mention synthetical indigo, because this substance was the most difficult of all to synthesize, and on the other hand was a great commercial success.

"This synthetical product is not only much purer in composition and color than the natural dye stuff, but also considerably less expensive. On this account, the cultivation of the indigo plant in India has diminished to one-sixth of the original extent, and will, to all appearances, soon disappear altogether.[4] Woolen and cotton goods are now dyed with German indigo even in Asia, to which continent a quantity of indigo worth no less than $9,500,000 was exported in the year 1909.

"While on this subject I may refer to the two most important coloring matters of animal and vegetable life, chlorophyll and hæmoglobin. The former plays an important part in the chemical process upon which all life depends—I refer to the conversion of the atmospheric carbon dioxide into sugar, which takes place in green leaves under the influence of sunlight. The red pigment in the blood fulfills in our own bodies the important function of transporting the oxygen from our lungs to the tissues, thus rendering possible that process of combustion which forms the basis of our bodily and mental strength."

The lecturer here showed two specimens of pure chlorophyll, of which one was crystalline. He remarked: "I owe these rare preparations to Prof. R. Willstätter, of Zürich, who of recent years has been studying this coloring matter with remarkably successful results. Hæmoglobin has also lately been thoroughly investigated in Stuttgart and in Munich, and the remarkable conclusion has been drawn from these investigations that chlorophyll and hæmoglobin are closely related. This fact thus denotes a species of consanguinity between the animal and vegetable kingdoms. This must, however, be of great antiquity—that is to say, to date from remote times, when the animal and vegetable kingdoms were as yet not distinct.

"Of greater commercial importance than the coal-tar dyes is India rubber. Its consumption is continually increasing, and is estimated at some 70,000 tons yearly, an amount corresponding in price to about one hundred and seventy-five millions of dollars. You can therefore readily understand that this subject has attracted the attention of synthetic chemists, and for the last nine months one has heard, even in public, of attempts to prepare synthetical India rubber. In fact, in August, 1909, Dr. F. Hofmann and Dr. C. Coutelle, chemists to the Elberfelder Farbenfabrik, succeeded in devising a practical process for its synthesis. The starting material is a volatile, mobile, and colorless liquid termed isoprene,[5] which in turn can be readily synthesized from even simpler substances.

"This liquid is converted into India rubber merely on heating in closed vessels." The lecturer here exhibited a sealed glass tube which had been originally filled with a mobile liquid, isoprene, but which after heating contained a jelly-like mass of synthetical India rubber. Pointing to this, he said: "When thus prepared on a large scale, the substance is somewhat denser and of a light yellow color. That this product is really India rubber has been definitely established by the scientic investigations of Prof. Harries in Kiel, a high authority on this subject, who has since independently devised another process for the same purpose.

"When synthetic chemistry has once taken possession of such a field, it is not confined to the particular product occurring in nature, but can bring forth a whole series of similar substances. Other rubber-like substances have been prepared, not from isoprene, but from similar liquids, such as dimethylbutadiene. Such products are termed homologues. They possess properties closely resembling those of India rubber, but differ slightly in chemical constitution. It is, as yet, not decided which of these synthetical substances forms the most suitable substitute for India rubber. The same applies to the far more important question of cost of production. But when one considers the fate of natural indigo, of madder, and of other natural products, one may hope to see synthetical India

[4] The recent work of Bloxam and his collaborators has demonstrated the possibility of recovering from the leaf a yield of indigo increased to such a degree that the cost of production is certainly no more than that of the synthetical product. Furthermore, the natural indigo is stated by some authorities to possess certain benign impurities which render it more suitable for dying purposes.

[5] First shown to yield India rubber in 1892 by Sir William Tilden (*Chem. News*, lxv., 265).

rubber gradually enter into successful competition with the naturally occurring commodity.

"Camphor, which may be placed in the same chemical category as India rubber, is also prepared artificially on a large scale. The first firm to manufacture synthetical camphor was the Chemische Fabrik auf Aktien (formerly Schering), of Berlin, but other firms are now following suit. By this, the camphor monopoly, which the Japanese government was able to establish after the annexation of Formosa, was broken down."

Passing on to a somewhat different field, the lecturer now showed to his audience samples of an artificial resin closely resembling amber in its external characteristics, and capable of serving as a substitute for that substance in the production of such articles as necklaces, combs, cigar holders, etc. Samples of such articles were submitted, which had been placed at the disposal of Prof. Fischer by the Bakelite Company, Bakelite being the trade name of the material, which is prepared by a process recently worked out on a technical basis by the American chemist Baekeland.

Referring next to the association of synthetic chemistry with medicine, the lecturer remarked that workers in this field were actively engaged in the pursuit of the discovery of new medicaments, and that the great amplitude of this subject compelled him to mention only a few instances. Thus, he showed to the audience a bottle containing a white powder—veronal—which is a hypnotic largely employed at the present day. It is in no way connected with the older vegetable narcotics, such as opium, etc., but is entirely a synthetical product. He then pursued his subject.

"Organic synthesis is not limited to vegetable products only, but embraces equally fearlessly substances of animal origin. An instructive example of this may be found in a remarkable compound (adrenalin) which is formed in our own bodies in the suprarenal glands, and which plays an important part in the regulation of the blood pressure. Shortly after its isolation in a pure condition from these glands, Dr. F. Stolz, chemist to the dye factory at Höchst, was able to synthesize it from constituents of coal-tar. This synthetical product has now been placed on the market by the Höchst firm under the name of 'Suprarenin.' A very dilute solution of this substance causes a powerful contraction of the blood vessels, and consequent dispersal of blood from the tissues. A skin surface well charged with blood—as, for instance, a red nose—is instantly rendered quite pale on painting it with such a solution. Unfortunately, the color is not evenly discharged, owing to the varying permeability of the epidermis, and as the action of the drug soon ceases, with return of the original redness, adrenalin is not suitable as a cosmetic. On the other hand, it finds most useful application in surgery, as by its means certain incisions can be made without loss of blood; this is found particularly convenient for operations on the eye, mouth, and nose.

"Flora's fairest children, the sweet-scented flowers, must also submit to competition with synthetic chemistry. The scent industry has received a powerful impetus from synthesis, and yearly turns out in Germany alone goods of the value of more than ten million dollars. Among the products of this industry may be mentioned ionone, an artificial violet scent discovered in the laboratory of this university by the late Prof. F. Tiemann, and manufactured by Messrs. Haarmann and Reimer in Holzminden. The contents of this bottle would be sufficient to envelop, not only the Ministry of Education, but the entire avenue 'Unter den Linden' in an atmosphere of violet perfume, for the osmophoric value of these substances is extraordinarily high.

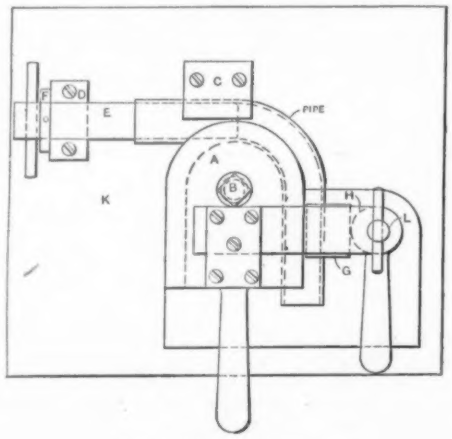
"In contradistinction to the simple ionone, the majority of the natural odors of flowers are due to complex mixtures of different scents. These, nevertheless, have been successfully reproduced. Among scents so prepared are lily of the valley, mock orange, lilac, tuberose, and, finally, the greatest achievement, synthetical attar of roses. Although the natural oil from roses contains about twenty different odorous substances, the chemists of the scent factories at Leipzig (Heine & Co., Schimmel & Co.) have succeeded after laborious research in isolating all the components, synthesizing these, or preparing them from less costly oils, and then reuniting them in the proper proportions. It now requires a most sensitive nose indeed to distinguish the synthetical attar of roses from the natural product.

"These examples show the success which has followed the encroachment of synthetic organic chemistry in nature's domain. What I have already said is sufficient to prove that chemistry, as well as all natural sciences, is the true field of unlimited possibility. The Kaiser Wilhelm institutes are henceforth to take part in the expansion of this field and the appropriation of the treasures hidden therein.

"It is, of course, not to be expected that they will entirely supplant all the older scientific institutions. We of the older institutions do not feel by any means so weak as willingly to allow such an event to occur. On the contrary, we shall exert our best energies to maintain a keen competition with the younger institutes. This will serve to keep both sides fresh and active."

Pipe-Bending Device

The illustration shows a pipe-bending device which will be of value to anyone wishing to bend pipe without the trouble of filling it with sand or other materials. The mandrel *E* is held on base *K* by the steel block *D*. Stop collar *F* is set and pinned on the mandrel in such a position as to allow the end of



PIPE-BENDING DEVICE.

the mandrel to project slightly past the center line of swivel block *A*, which is pivoted at *B*, and rounded out for the pipe. The backing block *C*, which also fits the pipe, is set so as to allow the pipe to slide over the mandrel E, and keeps it from buckling while it is being drawn off the mandrel.

The pipe is shown in the illustration after having been bent at right angles. Before making the bend, the swivel block *A* is set in a position parallel with the mandrel *E*, and the end of the pipe is then placed on the mandrel. It is held to the swivel block by means of a sliding block *G* which is locked by the eccentric lock-lever *H*. After making the bend, the lock-pin *L* is pulled out, after which the block *G* and the eccentric lever *H* can be removed; the pipe may then be pulled off the end of the mandrel.—*Machinery.*

The Ferry Total Reflectometer

The name "total reflectometer" is given to an instrument designed for the measurement of the optical refractive index of a liquid by means of the phenomenon of total reflection. A recent issue of *Prometheus* describes a new form of the instrument, invented by the French physicist Ferry.

If *AB* (Fig. 1) represents the surface of separation

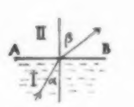


Fig. 1

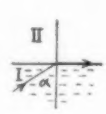


Fig. 2

Fig. 3

between water *I* and air *II*, a ray of light directed upward through the water at a small angle of incidence α is reflected at the surface and emerges at a larger angle β, such that the ratio $\frac{\sin\beta}{\sin\alpha}$ is equal to the ratio of the velocities of the ray in air and in water, and is therefore constant for all angles of incidence (so long as any refraction occurs). This ratio is called the refractive index from water to air,

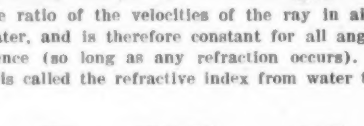


Fig. 4

for light of the particular wave length employed. If the angle of incidence α is gradually increased, the angle of refraction β increases correspondingly, until it becomes a right angle, and the refracted ray coincides with the surface (Fig. 2). In this case $\sin\beta = 1$, so that the refractive index is equal to $\frac{1}{\sin\alpha}$. This value of the angle of incidence is called the critical angle, for if the ray, in the water, makes a still larger angle with the normal to the surface, it cannot emerge, but is totally reflected at an angle β equal to its angle of incidence α (Fig. 3).

Kohlrausch's total reflectometer, the instrument most commonly used for measuring the refractive index of a liquid by means of total reflection, requires two settings and two readings for each measurement, but Ferry's apparatus requires only one reading and no accurate adjustment.

A hemispherical cavity in a cubical block of glass (*W*, Fig. 4) contains a concentric glass hemisphere of slightly shorter radius, and the space between the hemisphere and the wall of the cavity is filled with the liquid. When the cube of glass is viewed with a telescope *R*, a dark ring, caused by the total reflection of some of the incident rays, is seen. The internal diameter of the dark ring varies according to the refractive index of the liquid. This diameter is measured with a micrometer eyepiece. From the result of the measurement it is possible to calculate the index of refraction from the liquid to the glass, and hence, the index of refraction from the liquid to air, or vacuum, when the index of the glass is known. The use of the instrument, however, is simplified by graduating the head of the micrometer screw in units of refractive index, so that the refractive index of the liquid is obtained by direct reading, without calculation.

Short Cuts in Multiplication

It is ridiculous how much unnecessary trouble some people—let me say most people—take when they have a bit of multiplication to do. Take the three examples here given. In the first, by the long way, there are sixteen figures and four operations; but by simply multiplying by the factors 4, 8 and 4, the product is there without any addition.

In the second example, which is done in two long and hence wrong ways, of which the second is the quicker, there are still by either of these ways twelve intermediate figures and four operations; whereas, if one would only add three ciphers and then subtract the multiplicand, the "answer" would be there with only six figures and two operations.

In the third example, by setting three ciphers as before to the multiplicand, and subtracting twelve times itself, the answer is obtained by writing only ten intermediate figures and performing two operations. In the last two examples writing the ciphers is really not necessary. Why take so much trouble? One can just imagine them there.

Wrong Way.	Right Way.
1729	1729
128	6916
	55328
13832	221312
3458	
1729	
221312	

Wrong Ways.	Better:	Right Way.
999	735	735000
735	999	735
4995	6615	734265
2997	6615	
6993	6615	
734265	734265	

Wrong Way.	Right Way.
345678	345678000
988	4148136
2765424	341529864
2765424	
3111102	
341529864	

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